US Army Corps of Engineers
San Francisco District

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

FINAL FEASIBILITY REPORT
24 September 1996

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13. ABSTRACT *(Maximum 200 words)*
The report presents information developed in the course of a multi year investigation of the need for shore protection and storm damage reduction. The study area was 8.6 miles of the Pacific coast, known as Ocean Beach, in the City of San Francisco, CA. The study area extended from Cliff House to Fort Funston. The beach portion of the study area is in the Golden Gate National Recreation Area, under the jurisdiction of the National Park Service. Facilities threatened with damage included the Great Highway, parking lots of the GGNRA, a buried storm and sewer water transport box, a sewer pumping plant and ultimately houses and businesses. The report records the Ocean Engineering, Economic, and Geotechnical studies used to formulate and analyze a variety of alternative measures, including structural seawalls and revetments, as well as beach and dune nourishment. The final analysis indicated that most of the study area, while not absolutely safe, had a low probability of erosion. In the one area with a possible federal interest, the sponsor was unable to agree to cost share at the time of the report. Therefore the study was terminated. The sponsor will pursue other measures not requiring federal cost sharing.

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1. SYLLABUS

The Ocean Beach Feasibility Study is a storm damage prevention and shore protection study with a primary emphasis on providing protection to public facilities by means of dune nourishment or construction of a seawall. During the course of the Feasibility Study, it was determined that the dune nourishment alternative was not viable and, therefore, lacked a Federal interest. It was also determined that study Reach I (from near Noriega St. to Moraga St.) and Reach II (south 300 feet from end of the seawall promenade) lacked a Federal interest because the projected damages were not great enough within the fifty-year project life. This does not mean that these reaches are absolutely safe from further erosion. However, the rate at which these reaches are expected to erode is low. Reaches I and II are projected to be relatively stable within the next 50-years.

A Federal interest was determined to exist however for Reach III, South of Sloat Blvd, and the recommended alternative was determined to be a seawall similar to the existing buried seawall at the foot of Taraval Street. The local sponsor, the City and County of San Francisco has indicated that it was reluctant to continue participation in a joint study. In a letter dated May 1, 1996 the city stated that it is unable to cost share in the construction of a seawall. This has resulted in termination of the Feasibility Study.

This report summarizes the plan formulation considered. The attached appendices summarizes all study work performed to date and include bibliographic data. It is intended to preserve information developed during the course of the study. Some appendices are not as complete or polished as others. There was a conscious decision to curtail funds and effort when it was decided to halt the study. The information developed and presented here, taken as a whole, justifies the conclusions and recommendations.

2. STUDY AUTHORITY

The Congress of the United States has directed the Corps of Engineers to conduct a study of beach erosion along the shores in San Francisco County, California, with the following resolution adopted on 3 August 1989 by the Committee on Public Works and Transportation, U. S. House of Representatives:

> *"Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, that the Secretary of the Army, in accordance with Section 110 of the Rivers and Harbors Act of 1962, is requested to make, under the direction of the Chief of Engineers, studies of the shores in San Francisco County, California, from the south county line to the Golden Gate Bridge and such adjacent shores as may be necessary, in the interest of providing protection to public facilities, storm damage prevention, and other related purposes."*

The City of San Francisco has requested that the San Francisco District Corps of

Engineers, undertake a study of shoreline erosion at Ocean Beach, in San Francisco, California. The erosion of unprotected shoreline along Ocean Beach poses a serious threat to the Upper Great Highway and the City of San Francisco's Sewer Transport System.

3. STUDY PURPOSE AND SCOPE

The purpose of this feasibility study is to determine the feasibility of Federal assistance in protecting public facilities along the Ocean Beach shoreline in the City and County of San Francisco from storm damage. The study scope assessed the Federal interest in five study alternatives - Dune Nourishment, O'Shaughnessey-Type Seawall protection, Taraval-Type Seawall protection, Rubble Mound Structure protection, and No-Action - on three project reaches within the study area.

4. STUDY AREA

The study area is located in the City and County of San Francisco. The County of San Francisco stretches 8.6 miles along the Pacific coast from the southerly county line to the Golden Gate Bridge (Figure 1). Of this length, approximately 6 miles of coast consist of sandy beaches and the remaining 2.6 miles are rocky headlands or bluffs. Ocean Beach extends from Fort Funston to the Cliff House, a distance of approximately 3.6 miles. The Ocean Beach corridor comprises the area from the westerly curb of the Lower Great Highway to the ocean and includes beach, dunes, seawalls, the Upper Great Highway, sewer transport boxes, parking lots, a recreational trail, and a landscaped linear park. Golden Gate Park lies just inland on the northern third of the beach while the San Francisco Zoo is located just inland on the southern third of the beach. Ocean Beach is located in a major urban area and serves not only residents of the City and County of San Francisco, but also visitors from all over the world.

5. HISTORY OF STUDY AREA

Ocean Beach serves as a recreation area and as a buffer between the Pacific Ocean and the Great Highway. Since the 1840's this strip of land has been used for transportation and recreation. Toward these purposes, various roadways and buildings have been constructed along the beach. Storms and erosion have continually threatened or destroyed these structures. The Ocean Beach study area has had urban impacts for more than 100-years; houses, roads, seawalls, buried sewer structures & construction debris.

In the 1920's, the City of San Francisco planned to design and construct a concrete seawall along the entire Ocean Beach shoreline to protect the highway and to make a boardwalk/amusement tourist area. Economic conditions in the 1930's halted construction after only one mile of the project was completed. This seawall is known as the O'Shaughnessy Seawall, or esplanade, and it extends from the Cliff House south to Lincoln Way. The 665-foot long Taraval seawall was constructed in 1941 to protect the pedestrian underpass at Taraval

Street and the Great Highway. Sand deposition from natural processes has since buried this wall and modified dune habitat covers this reach; the low profile wall (at elevation +13' MLLW) is only visible during extreme erosion events

In 1972, the City and County of San Francisco gave all of the land at Ocean Beach west of the Great Highway right-of-way to the Golden Gate National Recreation Area (GGNRA). To alleviate pollution of the Pacific Ocean from the discharge of untreated effluent, the City and County of San Francisco constructed the Westside Sewer Transport Box under the Great Highway in 1983. In March of 1988, construction of another seawall/promenade was begun to protect the Great Highway and sewer box between Noriega and Santiago Streets from major storms. This new seawall was completed in 1993.

Ocean beach is subject to direct attack from waves approaching from the southwest to the northwest. High tides accompanied by large waves have caused recession of the dune escarpment along the central and southern portions of the beach. Periodically, there is acute erosion of the beach and dunes between Moraga and Noriega Streets, Taraval and Ulloa Streets, and from south of Sloat Boulevard to the Fort Funston cliffs. This erosion threatens shoreline improvements, local infrastructure, natural resources, public property and recreational activities. Previous studies have shown that major storms have eroded and will continue to erode sections of the beach and dunes.

6. HISTORY OF CORPS OF ENGINEERS STUDIES

The U.S. Army Corps of Engineers has completed five major studies of the San Francisco County coastline, which investigated seven alternatives within the current study area. The alternatives investigated and the five major studies are listed below.

Fort Funston, California, Beach Erosion Control Study, San Francisco District, Corps of Engineers, 1940, unpublished. This report determined it would not be feasible to construct a concrete seawall to protect the bluffs along Fort Funston.

Cooperative Beach Erosion Study of the Coast of Northern California, 1965 and 1975, by the Corps of Engineers and State of California. These were basic data gathering programs. Data included wave data, aerial photography, hydrographic surveys and sand sample analysis.

National Shoreline Study, California Regional Inventory, 1971. This report included shoreline configuration, ownership, use, type of beach, existing erosion protection, erosion potential and suitable protection of the California Coast.

Shores of San Francisco County, California, Beach Erosion Study, 1972, San Francisco District, Corps of Engineers. This study investigated the 8.6 miles of coastline along the City and County of San Francisco. This report recommended further study of the area between Lincoln Way and Fleishhacker Pool, a former City landmark subsequently destroyed, which was located near the San Francisco Zoo. The study found the coastline north of Lincoln Way and south of Fleishhacker Pool did not warrant further analysis. These areas were excluded because of the undeveloped nature of the reaches and lack of a critical erosion problem. The study did not progress into advanced analysis as Ocean Beach was incorporated into the Golden Gate

National Recreation Area in 1972. At the time this study was discontinued, preliminary studies had been conducted on seven alternatives. These alternatives include: no action, extension of the Ocean Beach Esplanade, construction of a rubble-mound seawall, groin construction, placement of beach fill, dune stabilization, and construction of an artificial lagoon and beach fill. Preliminary findings indicated that detailed studies of the dune stabilization alternative should be conducted for the reach of shoreline from Lincoln Way to Sloat Boulevard. It also recommended that detailed studies of a rubble-mound seawall be conducted in the vicinity of Fleishhacker Pool.

Ocean Beach, San Francisco, California, Feasibility Report, July 1979. This Corps report was prepared for the National Park Service, Golden Gate National Recreation Area (GGNRA) to evaluate the erosion problem at Ocean Beach and develop alternatives for long-range beach-erosion control along the beaches of San Francisco. This study concluded "With time the beach from Noriega Street south will recede, reducing or eliminating the dunes and restricting the usable width of corridor. The exact time frame is not known because of the variability and uncertainty of the erosion rate." Three alternatives were developed and include: a beach fill plan, a rubble seawall plan, and a dune toe protection plan. The National Park Service has not implemented any of these or other alternatives to provide shoreline protection at Ocean Beach.

Prior Study Alternatives: The seven alternatives investigated included the following

Extension of Ocean Beach Esplanade (1972)
Rubble-Mound Seawall (1972, 1979)
Beach Fill (1972, 1979)
Dune Stabilization (1972)
Artificial Lagoon and Beach Fill (1972)
Dune Toe Protection (1979)
Groin Construction (1972)

Other Studies: Other studies in the vicinity of Ocean Beach, which were identified in the report for the reconnaissance phase of the current study, are listed in Attachment A.

7. CURRENT CORPS OF ENGINEERS STUDY

The current study which was authorized in 1989, began with the funding of the reconnaissance phase in 1990. The reconnaissance phased determined that there was a Federal interest in providing shoreline protection along Ocean Beach in the City and County of San Francisco. The feasibility phase, begun in 1991 examined the alternatives in greater detail to determine the extent of the Federal interest and recommend an implementable solution to the problems identified in the reconnaissance phase.

8. STUDY REACHES

The reconnaissance study concentrated on the development of alternatives for three reaches parallel to the Great Highway. The reaches are essentially, northern beach; central beach

and southern beach. The study concentrated on three reaches with erosion problems. The limits of the reaches are based on historical information and physical conditions as measured and obtained through analysis of historical aerial photos and numerical modeling of shoreline processes. The limits of these reaches were first established in the reconnaissance phase and then refined and modified during the feasibility study based upon the results of additional coastal engineering studies. The proposed project reaches as defined in the feasibility study are described below and shown in Figure 1.

Reach I From 180 feet south of Noriega St. to the center line of Moraga Street. (870 feet in length)

Reach II From the south end of the New Great Highway Seawall Promenade to 300 feet south (approximately 50 feet south of the north end of the Taraval Seawall). (300 feet in length)

Reach III From 80 feet north of Sloat Blvd centerline, southward for 2,680 feet. This area encompasses both Park Service parking lots. (2,680 feet in length)

9. SUMMARY OF ENVIRONMENTAL ANALYSIS

At the conclusion of the reconnaissance study, and at the public scoping meeting for the feasibility study (NEPA - Environmental Impact Statement [EIS]), the dune nourishment alternative was the recommended alternative. The feasibility level analysis has demonstrated the seawall alternative to be more feasible than the dune nourishment alternative. If the study were re-opened, with a Taraval-Type Seawall as the favored alternative, it will be necessary to re-open the scoping process and the U.S. Fish and Wildlife Service coordination. It should be noted that the initial scoping meeting occurred before the critical nature of the problems south of Sloat Blvd were realized.

The existence of snowy plovers were documented in the Environmental Assessment (EA) for the reconnaissance level study, and further information, detailed below, was obtained during feasibility level before project was stopped. Nevertheless, detailed independent investigations of snowy plover activity were not undertaken as part of this feasibility study. At the time the Corps stopped work on this project, there was no conclusive information to either verify or refute the contention that snowy plovers may be nesting at the base of the O'Shaughnessey seawall at Ocean Beach.

Endangered Species: The State-listed bank swallow and the Federally-endangered western snowy plover are the only two legally protected species known to be residents of Ocean beach.

Bank Swallow: The bank swallow nests at the Fort Funston cliffs located near Reach 3 at Ocean Beach. Any construction activities in Reach 3 should be limited to the "September through March" time frame so as to not disturb resident bank swallows. Construction activity should be avoided from the "beginning of April to the end of June" (spring & summer) when bank swallow nesting at Fort Funston cliffs is at it's peak.

Snowy Plover: No historic records of the nesting of snowy plovers at Ocean Beach have been obtained by the Corps. In the Fish and Wildlife Service's "Proposed Designation of

Critical Habitat for the Pacific Coast Population of the Western Snowy Plover (March 2, 1995; Volume 60, Number 41) [Proposed Rule], the Service proposes to designate 28 areas along the coast of California, Oregon, and Washington as critical habitat areas. The coastal population of the western snowy plover consists of both resident and migratory birds. Some birds winter in the same areas as breeding, while other birds migrate either north or south to other wintering areas. They generally arrive at their breeding/wintering grounds in September, and leave for their nesting grounds by mid-April. In reviewing the "Proposed Rule for the Western Snowy Plover", it does not appear that Ocean Beach is designated as one of the 28 critical habitat areas for nesting.

In the past, observations of "territorial behavior" by snowy plovers at Ocean Beach have been reported, and nesting of snowy plovers (March 1st to September 15th) have been reported at Point Reyes located 30 miles to the northwest of the study area. Due to the high recreational use of Ocean Beach by beach-goers and their unleashed dogs (note: on January 1, 1997 a new policy goes into effect at Ocean Beach that bans off-leash dog walking in the area of Ocean Beach from the south edge of Golden Gate Park to Sloat Boulevard), it is highly unlikely that any successful nesting of snowy plovers occurs at any areas of intertidal beach and foredune habitat at Ocean Beach. If beach nourishment were the recommended alternative, beach nourishment activities may also have the potential to benefit nesting or wintering snowy plover habitat in areas experiencing erosion problems such as Reach 3.

The National Park Service recently reported that approximately 70 snowy plovers winter and rest at Ocean Beach during part of the year. In Reaches 1 and 2, construction activities should be limited to a "late April to July " time frame to avoid disturbance of wintering and resident snowy plovers. In Reach 3, construction activities should be limited to a "September through March" time frame to avoid any disturbance of snowy plovers wintering, breeding, resting and feeding (not nesting) in this reach of Ocean Beach. Apparently, snowy plovers inhabit (rest and feed and winter) Reaches 1 and 2 at different times of the year than in Reach 3.

Ideally, with two legally protected species located at Reach 3, the bank swallow and snowy plover, and until further information is obtained of any documented nesting of snowy plovers at Ocean Beach, any construction activity should be limited to the "September through March" time frame, in order to minimize any impacts to these two species. However, if the need for a construction window outside this time period arises, a thorough evaluation of any potential impacts to these species must be conducted and approved by the Fish and Wildlife Service, and mitigation measures implemented should any potential impacts occur. Therefore, the Fish and Wildlife Service would be a critical member in any evaluation of this type.

10. SAND ANALYSIS

Appendix D, the Geotechnical Analysis and Appendix E, the Cost Analysis, record information which was significant in formulation and evaluation of the problems and

alternatives, including the analysis of sources of sand for dune and beach nourishment. They are included to record and preserve the information developed in the course of the reconnaissance and feasibility studies.

Appendix D, the Geotechnical Analysis, presents specific geologic information on the project area and the alternatives, evaluations of foundation conditions and design of the alternatives. It also describes and presents information on soil and sand including possible sources of material that was gathered in the course of the Feasibility Study. It includes a sand source analysis, and records of boring logs of material sampled in the course of the study.

Appendix E, the Cost Analysis, presents additional information developed on alternative sources of sand for the beach nourishment and the dune nourishment alternatives. It includes information on costs of potential sand sources from San Francisco Bay and off shore. The estimated cost of supplying sand for dune and beach nourishment used in the cost evaluations is generally based upon existing developed commercial sand sources that are currently available. The alternative sources investigated in the Sand Analysis demonstrate the potential for additional new sources which would require additional study as well as political and regulatory action to implement.

11. COASTAL ENGINEERING STUDIES

The initial feasibility study numerically modeled both the cross shore and along shore sediment transport processes in order to get a comprehensive representation of the system. This initial effort was not entirely successful, however useful information was gained (See Appendix A). Efforts to model the alongshore transport were not met with success during the calibration phase of modeling, at which point the alongshore transport modeling effort was halted.

Although the alongshore transport modeling effort was met with little success due to the inherent complexity and variability of the natural system, numerical modeling of the cross-shore sediment transport was successful. SBEACH, was used to model the cross-shore sediment transport for each of the three reaches identified earlier in this report. Each reach was modeled to determine the erosional effects of incident waves. Numerical modeling results were verified against available documented shoreline data and anecdotal common knowledge of persons with long-term familiarity with Ocean Beach. Calibration and verification of the model was successful and the analysis is considered to be valid for the cross shore sediment transport at Ocean Beach. The coastal engineering studies and analyses are presented in Appendix A.

To lend three dimensional context to the two dimensional cross shore sediment transport modeling, Moffat & Nichol Engineers was contracted to conduct a qualitative study of the sediment processes at Ocean Beach. This study involved a through review of available historic data at Ocean Beach to attempt to quantify the movement of sediments in the area. Although the numerical modeling results of alongshore transport proved to be inconclusive due to the inherent complexity and variability of the natural system, some narrowing of uncertainties is possible using the Moffat & Nichol study. In addition, a through analysis of erosion rates was conducted along Ocean Beach (Sand, 1995), the results of which were also used to gain insight into the sediment processes at Ocean Beach.

The feasibility phase coastal engineering study results for the Ocean Beach study area, involve significant revisions to the past conclusions regarding the evaluation of alternatives. The feasibility phase analysis shows that the potential for erosion damage is not as great as was first anticipated in the study area north of Sloat Blvd. As part of the coastal engineering study, erosion quantities were estimated for the three reaches as described in Appendix A. Long-term erosion was modeled by repeatedly sampling probability distributions of single storm season dune width erosion values. Twenty-four years of wave and water level data were used to establish the best probability distribution of dune erosion. These probability distributions were used in simulations which estimated the mean time to erode a distance such that the Great Highway would be impacted.

Reach I distributions were sampled until 100 feet of dune had eroded. If 100 feet of dune had eroded the road would have to be closed. The mean time until this occurred was 90-years. The probability that the sewer box would be impacted once the dune had eroded 100 feet was taken to be 0%. This means it would not be significantly impacted within the 50 year economic life of a project.

Reach II distributions were sampled until 90 feet of dune had eroded. If 90 feet of dune had eroded the road would have to be closed. The mean time until this occurred was 55-years. The probability that the sewer box would be impacted once the dune had eroded 90 feet was also taken to be 0%. This means it would not be significantly impacted within the 50 year economic life of a project.

Depending on which of four different local management scenarios was chosen in Reach III, different consequences could be modeled for the without project condition. The first scenario assumed that the parking lots were repaired once half of them were damaged or erosion of 20 feet had occurred. The mean time until this occurred was 1-year. Under this scenario, there was a 36% chance annually that the road would close and a 15% chance annually that the sewer tunnel would break. Sewer tunnel breakage assumes the erosion has reached the sewer and the sewer breaks under buoyant force loads. The second scenario for Reach III assumed that the road and parking lots were repaired once they were damaged or erosion of 65 feet had occurred. The mean time until this occurred was 3-years, and there was 22% chance annually that the sewer tunnel would break under this scenario. The third scenario for Reach III assumed that the sewer, road and parking lots were repaired once damaged, or erosion of 104 feet had occurred. The mean time until this occurred was 6-years, and there was 1.6% chance annually that erosion would reach the treatment plant (200 feet of erosion would occur). The fourth scenario for Reach III, assumed nothing was repaired. Under this scenario, the mean time until erosion reached the treatment plant was 67-years. Other scenarios were considered but not used in the economic analysis.

12. STUDY ALTERNATIVES

The alternatives listed below have been considered in this current Feasibility Study.

The rubble-mound revetment & seawall alternatives were characterized as "hard", and the dune nourishment/replenishment plan & beach nourishment/replenishment plan were

characterized as "soft". The "soft" alternatives were initially viewed as potentially less environmentally intrusive and disruptive than the "hard" alternatives.

No-Action Under this alternative, no action would be taken to remedy the progressive storm erosion of the dunes which support and protect the Upper Great Highway, Westside Sewer Transport Box and Lake Merced Transport Box. These structures would be adversely impacted. The rate of erosion would vary in each of the three reaches and the time periods for the structures to be damaged would vary. The projected intervals until erosion damages occur, estimated by project reaches are shown in the Coastal Engineering Appendix. These structures are not expected to be damaged in Reach I & II within the period of analysis. The total value of the Great Highway and the Sewer Transport Boxes in Reach II is approximately $106-million, including $6.5-million for the Great Highway, $73-million for the Westside Transport, and $23-million for the Lake Merced Transport. Destruction of the Great Highway would greatly disrupt traffic and cause trip delays as evaluated in the economic analysis. Destruction of the sewer transport boxes would cause the combined storm water and sanitary sewer flows to pollute Ocean Beach, the coastal waters off the beach and constitute a public health hazard. It would also prevent recreational use of the beach.

Rubble-Mound Revetment The rubble-mound revetment alternative was considered as an alternative at the reconnaissance level, but was not developed further in the feasibility phase because of its unacceptableness. It was recognized in the reconnaissance phase that the rubble-mound revetment was clearly not implementable because it was not acceptable to the National Park Service and, from a safety perspective, was deemed not compatible by the NPS with the recreational use of the beach. It was included in the feasibility study array of alternatives to use in cost comparisons to determine separable costs for aesthetic and recreational purposes. A cross section of this alternative is shown in Figure 2.

The revetment alternative would be constructed on a 2-foot horizontal to 1-foot vertical slope. The revetment would include a toe structure from an elevation of +6 feet MLLW (Mean Lower Low Water) to -5 feet MLLW in order to protect against scour. The armor stone would have a minimum size of 2.3 tons and maximum size of 4.0 tons, the first underlayer a minimum size of 435 pounds and a maximum of 810 pounds. The width of the structure would be approximately 90 feet. During construction, additional width would be required at the toe for a two way construction road.

Seawall The seawall alternatives are modeled after structures that already exist along Ocean Beach and, therefore, have some record of efficacy and precedence for public acceptability.

Two types were considered, both based upon the design of existing structures in the study area, the O'Shaughnessy-Type seawall and the Taraval-Type seawall.

O'Shaughnessy The O'Shaughnessy-Type concrete seawall was constructed by the City of San Francisco along Ocean beach in the areas of greatest public access. The O'Shaughnessy seawall is combined with a walkway or promenade. This seawall is intended to be a visible and accessible public amenity. This seawall is the more costly of the two seawall alternatives. A cross section of this alternative is shown in Figure 3.

Taraval The Taraval-Type seawall is a steel sheetpile structure with a concrete cap, and below ground tie backs to anchor piles. The design is the same as what the City of San Francisco installed in 1941 at the foot of Taraval Street. It is a low cost structure with

few specific amenities. The existing installation of the Taraval seawall is currently buried under wind deposited sand. This alternative was considered where low cost was critical and where the structure was expected to be periodically or permanently buried. A cross section of this alternative is shown in Figure 4.

In Reach III, the proposed "Taraval-Type" seawall would be approximately 2,680 feet long; and have a crest elevation of 13 feet MLLW. The wall would be located along the western slope of the existing parking lot areas. The wall would be constructed of steel sheetpile and would have a concrete cap approximately 2.5 feet wide by 3 feet high, and be coated with gunnite to a depth of 10 feet MLLW. The design of the wall would anticipate overtopping, and a rock toe would be placed for overwash protection along the toe of the excavated slope approximately 30 feet eastward of the sheetpile wall.

After construction the wall would be covered with excess material from excavation. It is expected that the seawall would remain buried during part of the year and would be partially exposed during part of the year, depending upon the transport of sand onto and off of the beach in Reach III. This exposure would vary seasonally. The beach berm elevation can be as low as 10 feet MLLW, and the beach may lower to 6 feet above MLLW during winter storm periods with local scour depth reaching 0 feet MLLW, so typically no more than 3 to 6 feet of wall should be visible. Stairways would be located at intervals along the seawall to allow beach access while the wall is exposed. The proposed construction of the Taraval-Type seawall would temporarily impact and close off the south parking lot area during the construction period.

<u>Dune Nourishment/Replenishment</u> The dune nourishment or replenishment alternative is an attempt to use enhancement of a natural feature (the dunes) to prevent shoreline erosion damage. The Dune Nourishment Alternative would widen the existing dunes and provide for a sacrificial advance fill. When the sacrificial advance fill is eroded during a storm season it is replaced, before erosion from another storm season causes damage. The analysis indicates that the frequency of shoreline erosion damage would be reduced but damage would not be prevented completely. To determine Federal interest, the cost of the initial and continuing nourishment must be justified by the value of the damages prevented. The alternative would work in the following manner. Once the sacrificial advance fill is eroded, a request for Federal funding to nourish the dunes would be submitted. A two year funding cycle is assumed. After receipt of funds two years later, the dunes would be nourished to their advanced fill width and the process would continue. There is a possibility that public facilities might be damaged. Projected costs for those damages are deducted from the benefit estimates. A variety of dimensions of dune height and width were evaluated for each of the three reaches as described in Appendix A.

<u>Beach Nourishment/Replenishment</u> The beach nourishment or replenishment alternative is similar to the dune nourishment or replenishment alternative in that it seeks to use enhancement of a natural feature (the beach) to prevent or reduce erosion damage. It would consist of the initial placement of sand within the zone of wave action and then the subsequent replacement of sand. The beach nourishment / replenishment alternative differs from the dune alternative mainly in the locations where sand is placed and the

heights and widths of the sand placement.

During the reconnaissance phase this alternative was divided into two broad reaches, the northern and the southern, which included the reaches used for the other alternatives as well as the shoreline between those reaches. The northern reach would extend approximately 6,800 lineal feet south of Lawton Street to Vicente Street. Both reach I and II were within the northern reach. The southern reach would begin just north of Wawona Street and extend approximately 3,600 feet to the south. Reach III was a small part of the southern reach.

The sand would be placed by truck hauling and earth moving equipment. The beach nourishment alternative would require hydraulically placed sand to fill to elevation +15 feet MLLW with a 10 - horizontal to 1 - vertical seaward slope.

The beach nourishment / replenishment plan was eliminated from further consideration early during the feasibility phase because of the scale of the costs and impacts. The scale of costs and impacts was reexamined and reconfirmed in the later stage of the coastal engineering studies conducted for the feasibility study. It is included in the array of alternatives presented in this report because of the high level of interest among agencies involved in the feasibility study.

13. PLAN FORMULATION

The alternative plans considered in the feasibility phase of the study included the Beach Nourishment Alternative which is applicable to the entire study area, and alternatives applicable to the three specific reaches identified in reconnaissance phase as experiencing erosion. The Beach Nourishment Alternative was considered for a northern area which includes Reach I & II and southern area of Ocean Beach which includes which includes Reach III. The rationale for the Beach Nourishment Alternative and its major features were described in the Study Alternatives Section.

Benefits, costs, and environmental impacts were assessed for non-beach nourishment study alternatives in each of the three specific shoreline erosion reaches. The alternatives vary by reach and are; dune nourishment, a Rubble Mound Revetment (see Figure 2), an O'Shaughnessy-Type seawall (see Figure 3), and a Taraval-Type seawall (see Figure 4). The non-beach nourishment alternatives considered for each of the reaches are described below.

<u>Reach I</u> From 180 feet south of Noriega St. to the center line of Moraga Street. (870 feet). Alternatives considered in this reach include the following:

(1) A Dune Nourishment Program. This alternative would be primarily on Park Service property. In this Reach there is currently an eroding dune field, with a dune field to the north and the new Seawall Promenade to the south.

(2) An O'Shaughnessy-Type seawall, possibly with promenade. The existing Seawall would be extended to the north on City and County of San Francisco Property.

<u>Reach II</u> From the south end of the New Great Highway Seawall Promenade to 300 feet south (approximately 50 feet south of the north end of the Taraval Seawall). (300 feet). Alternatives considered in this reach include the following:

(1) A Dune Nourishment Program. This alternative would be primarily on Park Service property. In this Reach there is currently an eroding dune field, with the new Seawall Promenade to the North and the Taraval seawall to the south.
(2) An O'Shaughnessy-Type seawall possibly with promenade. The existing seawall would be extended south along its same alignment on City and County of San Francisco property. It would overlap approximately 50 feet with the Taraval seawall.

(3) A Taraval-Type seawall. The existing Taraval seawall would be tied into the new Seawall Promenade with a new Taraval-Type seawall on a straight line diagonal, in an attempt to keep it buried, for the most part. Following the construction of the seawall, the excavated sand will be used as beach/dune nourishment for the project. The nourishment will only use sand that has been excavated during construction and will only be done once. This alternative would be on Park Service property.

Reach III From 80 feet north of Sloat Blvd centerline, southward for 2,680 feet. This area encompasses both Park Service parking lots. (2,680 feet). Alternatives considered in this reach include the following:

(1) A Dune Nourishment Program. Currently this design has nourishment projected every 3 to 4-years and loss of half the parking lots every 3-years. This design does not appear feasible due to the frequency of damage to the shoreline and due to the frequency of nourishment required. Within this reach, there are eroding dunes with parking lots. There is a dune field to the north and tall coastal bluffs to the south. All construction work would be done on Park Service property.
(2) An O'Shaughnessy-Type seawall possibly with promenade, along whole Reach just seaward of existing parking lots (cross-section 35' wide).
(3) A Taraval-Type seawall approximately 80' west of and parallel to the parking lots. Sand excavated during construction would be used as a one-shot nourishment of the project.
(4) A Rubble Mound Revetment along whole Reach with crest just seaward of existing parking lots (cross-section 85' wide). No sand nourishment would be necessary.

14. COST ESTIMATES

Feasibility phase cost estimates were not prepared for the alternatives in Reaches I and II because the Coastal Engineering studies indicated that there would be insufficient damages within a 50-year project life to justify a Federal project.

The cost estimates for the hard alternatives evaluated for Reach III are based upon the cost estimates used in the reconnaissance report. In the case of the Rubble Mound Revetment and the O'Shaughnessy seawall these cost estimates were updated by modifying the quantities to reflect a slightly longer length of structure. The cost estimate for the Taraval-Type seawall is a new estimate based on a reevaluated design using the results of the refined coastal engineering studies from the feasibility phase.

The cost estimates for the three structural alternatives for Reach III are presented in

Tables 1, 2 and 3, in attachment B to the main text of this report. The average annualized values were determined using the current Federal Discount Rate of 7.625% and a fifty-year project life.

The cost of the sand used in the evaluation of the dune nourishment alternative is based on an examination of suitable available borrow sites with additions for revegetation. It was not considered appropriate to base the cost of this sand upon material from maintenance dredging or the San Francisco bar channel. This is because the sand analysis indicated that the grain sizes available from the bar channel were not coarse enough to be stable on the dunes and foreshore. In addition, there is no way to assure that the need for the beach to be nourished would correspond with the need for the bar to be dredged.

15. ECONOMIC EVALUATION

The economic evaluation of the potential for storm damage in the study area including Reaches I, II and III is presented in Appendix C. The potential for storm damage exists in the study area. Large and steep winter waves can erode much of the high-water shoreline and narrow the beach. Simultaneous, severe storms can erode the shore dunes at Ocean Beach which serve to support and protect the Great Highway and the Merced Sewer Box.

The major storms in 1983 removed 60 feet of protective dune in some locations and threatened the Great Highway in a matter of days. Without protection, a storm of equal size could damage the Great Highway, forcing its closure and causing long traffic backups, inconvenience, traffic reroutes and extra travel until repairs could be made. In addition, a storm greater than that of 1983 could break the Merced Sewer Box, creating an ecological disaster that would be difficult to correct and costing the City of San Francisco millions of dollars in damages.

Eight benefit categories were evaluated for all three reaches. The benefits for Reach III are displayed in the SUMMARY OF ANNUAL BENEFITS Table on page 12 in Appendix C. The average annualized values were determined using the current Federal Discount Rate of 7.625% and a fifty-year project life. The economic benefit categories include the following:

(1) Value of Travel Time Delays (Southbound Great Highway)
(2) Extra Distances Driven Cost, (Northbound Great Highway)
    (2a) Associated Value of Time Delay
(3) Value of Travel Time Delays on Other Arterial Costs
(4) Elimination of Costs to Repair the Great Highway
(5) Elimination of Costs to Repair Merced Sewer Transport Boxes
(6) Elimination of Two Parking Facilities and Associated Recreation Opportunities
(7) Elimination of Environmental Degradation and Fines
(8) Prevention of the Loss of Recreation and Enhancement of Recreation Opportunities

Benefits were calculated for two scenarios, with different assumptions regarding future repairs to the National Park Service Parking lots in Reach III. It is not permitted to claim economic benefits from reducing damages to facilities owned by a Federal agency unless the

Federal agency agrees to share in the cost of the project which generates the benefits.

In this instance the relatively inexpensive National Park Service parking lots in Reach III, are located between the damaging waves and the relatively more expensive highway and sewer facilities owned by the City and County of San Francisco. If the parking facilities are not repaired, the City's facilities are damaged more frequently, and benefits from preventing the damages are relatively high.

If the parking facilities are repaired, the City's facilities are damaged less frequently, and benefits from preventing the damages are relatively low. In effect, the parking lots delay damages to the sewer and highway.

The National Park Service has indicated in their letter to the Corps (Attachment A), that they are averse to interfering with the natural processes and protecting their parking lots. At the same time, they recognize the City's need to protect the highway and sewer. They propose that the measures to protect the parking lots, and or highway/sewer not be undertaken until some triggering event indicates that damage to the city's facilities is imminent.

With this understanding of the National Park Service position it is clearly not prudent to assume that protection of the parking lots would prevent damage to the highway and sewer. At the same time there is no way to rationally determine what trigger point will be agreed upon by the City and the National Park Service. Therefore, benefit estimates for the two scenarios of without project conditions were evaluated (i.e. not repairing the parking lots and repairing the parking lots) and are displayed below:

Average Annual benefits for Scenario 1 are $6,775,000. Assuming the parking lots will not be repaired, and the City's high value infrastructures are damaged more frequently.

Average Annual benefits for Scenario 2 are $4,504,000. Assuming the parking lots will be repaired, and the City's high value infrastructures are damaged less frequently.

16. EVALUATION OF ALTERNATIVES

No Action Alternative: Reaches I & II were found to lack the potential for economically justifiable shore protection measures. Therefore, "No Action Alternative " is the best alternative for these reaches. The coast would remain in its semi-altered natural state. The Coastal Engineering analysis indicates that in Reaches I & II, the Great Highway and the sewer transport boxes could be damaged, but are not expected to be damaged within the 50-year period of analysis.

In Reach III, portions of the dune embankments in the project area will continue to erode and the Great Highway and the parking lots south of Sloat Boulevard will be damaged, with the possibility of the sewer boxes being damaged as well. The severity and frequency of this damage to the Great Highway and sewer transport will depend upon future repairs to the existing parking and recreation facilities between the shore and the Great Highway. Repair and replacement of the parking and recreation facilities decreases the probability of the landward infrastructure. This procedure is described in detail in the Economic Analysis Appendix B.

The average annual benefits from preventing this damage repair scenario are $6,847,000, which includes $5,500 from Reach I (not realized for 90-years), $67,000 from Reach II (not

realized for 55-years) and $6,775,000 from Reach III,.

Action Alternatives: Although structural design alternatives for Reaches I & II cannot be recommended at this time, these project reaches should be monitored for future changes in erosion patterns.

For Reach III, of the original hard structure alternatives considered, (O'Shaughnessy-Type concrete seawall, Taraval-Type sheetpile seawall, and Rubble Mound Revetment), the Taraval-Type sheetpile seawall is preferred by NPS because it would remain buried most of the time and, thereby, have the least visual impact.

A Rubble Mound Revetment of the scale proposed, built on park lands was considered unacceptable to the National Park Service for reasons of safety, rodent problems, visual impacts, maintenance requirements, and its large overall footprint.

In addition, the National Park Service prefers to reserve the natural appearance of the beach to the greatest extent possible. For that reason they prefer the Taraval-Type seawall, which would be buried much of the year to the O'Shaughnessy-Type seawall which is intended to be a visible architecturally attractive feature.

Reach III: Inadequate protection from erosion is the major concern in maintenance of public roads and sewer transport boxes. This area containing the GGNRA parking lots, has experienced recent (1995) storm related damage and shore protection appears justified economically. The soft and hard alternatives considered in Reach III are discussed below. The average annual benefits are $6,775,000 from Reach III. The economic evaluation presented here uses a discount rate of 7.625 % and a project life of 50-years as specified in the appropriate guidance.

Dune Nourishment: The analysis determined that Dune Nourishment is not an effective measure, because damage would continue to occur frequently even with dune nourishment. Appendix A Table 10 displays the results of the coastal engineering analysis. This table indicates that if the dune nourishment alternative were implemented, the Great Highway would be damaged at least 14 times over the 50-year life of the project. Even though this alternative does appear to be economically justified under certain future conditions, if damages were experienced with the frequency displayed in the Table 10 of Appendix A, the project would be perceived by the general public to be a failure and a poor investment of public funds.

The average annual cost of this alternative (including the cost of damages to the road) is approximately $5,300,000 as shown in Table 10 of Appendix A.

The average annual benefit would be $6,775,000 as shown on page 12 of the Economic Evaluation Appendix B for the scenario with the greater benefits. This scenario assumes the parking facilities between the Great Highway and the shore would not be repaired or replaced if they were damaged or destroyed. The replacement issue depends upon the future actions of the National Park Service and the City and County of San Francisco, and is not resolvable at this time. If it is assumed that the parking facilities are replaced under the without project conditions, then the average annual benefits are $4,504,000.

The benefit-to-cost ratio is approximately 1.3 to 1.0 under the non replacement scenario; it is approximately 0.8 to 1.0 under the replacement scenario. The scenarios

differ in the assumed future replacement of the parking facilities between the shore and the Great Highway.

In summary, the analysis shows that this alternative might be worth while on the basis of the monetary evaluation, but is not the NED plan and would be a bad investment on the basis of public perception and operational inconvenience. This alternative is not recommended.

O'Shaughnessy-Type Concrete Seawall The average annual costs of this alternative as shown in Table 1 of Attachment B at the end of the main text are approximately $2,325,000.

As discussed for the previous alternative, the average annual benefit would be $6,775,000 as shown on page 12 of the Economic Evaluation Appendix B for the scenario which assumes the parking facilities are not replaced. Under the other scenario, the average annual benefits are $4,504,000.

The benefit-to-cost ratio is approximately 2.9 to 1.0 under the non-replacement scenario, it is approximately 1.9 to 1.0 under the replacement scenario. The scenarios differ in the assumed future replacement of the parking facilities between the shore and the Great Highway.

Taraval-Type Sheetpile Seawall. The average annual costs of this alternative as shown in Table 2 of Attachment B at the end of the main text of this report are approximately $914,000

As discussed for the previous alternative, the average annual benefit would be $6,775,000 as shown on page 12 of the Economic Evaluation Appendix C for the scenario which assumes the parking facilities are not replaced. Under the other scenario; the average annual benefits are $4,504,000.

The benefit-to-cost ratio is approximately 7.4 to 1.0 under the non replacement scenario, it is approximately 4.9 to 1.0 with the replacement scenario. The scenarios differ in the assumed future replacement of the parking facilities between the shore and the Great Highway.

Rubble Mound Revetment. The average annual costs of this alternative as shown in Table 3 of Attachment B at the end of the main text of this report are approximately $1,957,000.

As discussed for the previous alternative, the average annual benefit would be $6,775,000 as shown on page 12 of the Economic Evaluation Appendix B for the scenario which assumes the parking facilities are not replaced. Under the other scenario, the average annual benefits are $4,504,000.

The benefit-to-cost ratio is approximately 3.5 to 1.0 under the non replacement scenario; it is approximately 2.3 to 1.0 under the replacement scenario. The scenarios differ in the assumed future replacement of the parking facilities between the shore and the Great Highway.

Beach Nourishment/Replenishment Alternative: The reconnaissance study anticipated that the northern reach would require an initial placement of 3-million cubic yards of imported sand and an additional nourishment of 382,000 cubic yards every five years; the southern reach

would require an initial placement of 1.3-million cubic yards of imported sand and would require an additional 132,00 cubic yards of nourishment every 10-years.

During the feasibility phase of the study, evaluation of this alternative focused on the southern reach which includes Reach III since it was determined that the potential for erosion damage in Reaches I and II was not great enough to economically justify shore protection measures.

The evaluation of the southern reach indicated that the material quantities required for an effective beach nourishment program would have to increase at least ten times greater than previously thought. The amount of sand required over a 50-year project life would be on the order of 11-million cubic yards. The increase in required nourishment is based on revised design work as well as an order of magnitude estimate in the Moffat & Nichol 1995 report. Since it was not possible to develop a reliable numerical model of alongshore material transport process, it was necessary to use conservative estimates of the nourishment needed in order to provide a safety factor. This is considered appropriate because of the inherent unreliability of using beach nourishment as a storm damage reduction alternative at Ocean Beach.

The average annual cost of the beach nourishment alternative is estimated to be approximately $20,700,000. This is based on an initial placement of 3-million cubic yards and nourishment of 11-million cubic yards over a fifty year project life, using a cost per cubic yard of $45.42 (from the sand sources for the Dune Nourishment alternative), if future sources or reanalysis reduced this cost by as much as a third, it would still be impractical.

The average annual benefits from protecting all three reaches is $6,847,000, as discussed under the "No Action" Alternative. The benefit-to-cost ratio for this alternative is 0.33 to 1.0.

Based on this evaluation and the inherent uncertainty and unreliability of using beach nourishment as a storm damage reduction alternative at Ocean Beach, this alternative cannot be recommended.

While the northern reach was not evaluated further because of the apparent lack of Federal interest in Reaches I and II, it is believed that the situation in the northern reach would be similar. The analysis leading to this conclusion is presented in the Coastal Engineering Appendix A.

17. VIEWS OF NATIONAL PARK SERVICE

The National Park Service (NPS) operates and has jurisdiction over the Golden Gate National Recreation Area which includes Ocean Beach. Any plan to modify the shoreline for erosion protection or other purposes requires the concurrence of the National Park Service.

The institutionalized dividing line between the jurisdiction of City and County of San Francisco and the National Park Service is the seawall or the edge of the Great Highway where there is no seawall. This "dividing line" avoids problems of jurisdiction in routine maintenance of the seawall, the Great Highway and the underground sewer transport box. The documents which transferred the Ocean Beach property from the City and County of San Francisco to NPS contain a description of the boundary which is not in complete accord with the institutionalized boundary reflected in the working relationship between the parties. An attempt to calculate and

plot the boundary on topographic maps using technical descriptions in the original documentation from the transfer of the property was not successful. The institutionalized boundary may have been formalized in other documents since the transfer of the property.

Where possible, all alternatives were designed to be within the boundary of the property under the jurisdiction of the city and County of San Francisco. In some instances this was not possible. In addition, any alternative constructed on City and County of San Francisco jurisdiction property would impact the NPS jurisdiction property during construction.

The National Park Service and the City and County of San Francisco enjoy an essentially cooperative relationship at Ocean Beach. The National Park Service was contacted frequently during the reconnaissance and feasibility phases of the study. Their position is reflected in their letter dated 10 October 1995, presented in Attachment A. Their position is summarized and paraphrased below:

The NPS would support a "non-aggressive" approach to a structural solution constructed on NPS land if it were needed to protect the City's investment in the Great Highway and sewer treatment and transport facilities. In general they prefer alternatives which have the least possible footprint of hard structure, and their policy emphasizes avoiding hard structure and interference with natural processes. They preferred the Taraval-Type seawall since it was the least structural or the smallest structural alternative offered. They also favor the concept that the structure would be buried much of the year, at least initially. They prefer it over the O'Shaughnessy-Type seawall because it would preserve the natural appearance of the beach to a greater extent.

The National Park Service states unequivocally that they would not permit the construction of a rubble mound revetment of the scale proposed, built on park lands for several reasons including safety considerations, rodent problems, visual impact, and maintenance requirements (cost and disruption to visitors and wildlife)

During the initial feasibility studies there was concern about the issue of the Corps cost sharing with another Federal agency if the shore protection measures benefited that agency. In the case of the Ocean Beach feasibility study, the parking lots in Reach III could have received beneficial protection from protective measures constructed as part of a Federally authorized project. Coordination with the National Park Service revealed that they would not be able to agree to cost share due to their restricted budget. In addition, the previously stated policy of the National Park Service is to avoid interfering with natural processes. However, as a hypothetical example, if it were necessary for the NPS to participate in a Corps authorized project as a sponsor, it would be necessary for NPS to certify that expenditure of these funds was expressly authorized by statute.

The existing parking lot and rest-room structures were constructed by the City and County of San Francisco as part of a sewer treatment plant and transport project. The NPS has stated that if the facilities were destroyed, they would seek to identify alternative locations where they would not be threatened by erosion and storm damage.

18. VIEWS OF CITY AND COUNTY OF SAN FRANCISCO

The sponsor for the Ocean Beach Feasibility study is the City and County of San Francisco. By letter dated 27 July 1996, the sponsor requested that expenditures on the study be restricted while the direction and total cost of the study were re-examined. The City re-evaluated their desire to continue with the study. This examination included a revaluation of the results of the Coastal Engineering studies which indicated that Reaches I and II were not economically justified but that Reach III appeared to be justified. After completing additional specifically authorized studies to clarify the situation and allow coordination with the National Park Service to determine their position, the City furnished a letter dated 1 May 1996 (see Attachment A) which presented their position. The City indicated that they did not have the funding to pursue the Taraval-Type buried seawall, which is the only alternative both justifiable and acceptable to the National Park Service. The City requested that a "wrap-up", negative feasibility report be prepared to highlight all the work done by the Corps and others, and the positive findings for Reaches I and II (less damage potential than previously evaluated).

The City indicated that they would be developing an emergency plan to address the areas of extreme erosion and evaluate the need for reinforcements for areas south of Sloat Blvd.

19. PUBLIC INVOLVEMENT

This section briefly discusses the Feasibility Studies's public involvement program.

Public Meetings: On 10 December 1992, the Corps of Engineers in conjunction with the local sponsor, the City of San Francisco Department of Public Works, conducted a public workshop and environmental scoping meeting at the Lowell High School in San Francisco. The purpose of this workshop was to gather public comment on the proposed shore protection measures. Also in attendance were representatives of the U.S. Fish and Wildlife Service, the California Coastal Commission and the National Park Service, Golden Gate National Recreation Area. The meeting was also attended by members of the public.

Formal Agency Coordination: During the Feasibility Study, Coordination with the U.S. Fish and Wildlife Service (USFWS) was initiated in accordance with the Fish and Wildlife Coordination Act. The F3 Feasibility Conference was held on 17 February 1994, attended by the Corps and the City of San Francisco. In addition, numerous meetings were scheduled and held with the City of San Francisco, the National Park Service and the California Coastal Commission to report upon and discuss the progress of the feasibility studies. These meetings included the following. Feasibility Study status and progress meeting on 19 January 1995 attended by the Corps and the City of San Francisco. Another Feasibility Study status and progress meeting on 13 February 1995; also attended by the Corps the City of San Francisco and the California Coastal Commission. A Feasibility Study status and progress meeting was held to solicit input from the National Park Service on their preferences for the various project alternatives on 16 February 1995, it was attended by NPS, the Corps and the City of San Francisco. On 12 July 1995, another meeting was held to solicit input from the National Park Service. It was attended by the Corps, the City, the NPS and the Department of Interior National Biological Service

(acting as consultant to NPS). The project alternatives were presented and discussed and the project site was toured. On 17 June 1996, a meeting was held attended by the Corps, the City and the Public Utilities Commission to discuss progress and status of the Feasibility Study. On 8 March 1996, there was a meeting of the Corps, the City and the California Coastal Commission to discuss the type of information to be included in the negative report which the Corps was to prepare after the City determined that they could not support construction of the alternatives determined to be feasible.

Study Team: Throughout the Feasibility Study, staff from the City of San Francisco Public Works Department have been very helpful in conducting the study. The have voluntarily provided engineering, economic, topographic survey, historical and other useful data.

Local Sponsorship: Discussions have occurred between the Corps and the local sponsor regarding the progress and results of the Feasibility Study Phase. The sponsor has stated that at this time the City does not have funding to pursue the alternative in Reach III found to have the greatest benefit-to-cost ratio and also preferred by the National Park Service.

20. SUMMARY

The Ocean Beach Feasibility Study is a storm damage prevention and shore protection study; with a primary emphasis on providing protection to public facilities by means of dune nourishment or construction of a seawall. During the course of the Feasibility Study, it was determined that the dune nourishment alternative was not viable and therefore a Federal interest could not be determined. It was also determined that study Reach I (From near Noriega St. to Moraga St.) and Reach II (south 300 feet from end of the seawall promenade) lacked a Federal interest because the projected damages were not great enough within the fifty year project life. This does not mean that these reaches are absolutely safe from further erosion. However, the rate at which these reaches are expected to erode is low. Reaches I and II are projected to be relatively stable over the next 50-years.

The analysis presented in this report however, did demonstrates that there are several viable structural alternatives to prevent storm damage erosion in Reach III (south of Sloat Blvd.) of the Ocean Beach study area, which are economically justifiable. Because the structures would have to be built on National Park Service Land, the National Park Service was consulted and they indicated that they can support only the least obtrusive buried Taraval-Type seawall in Reach III at this time. The soft alternative of dune nourishment is also economically justified in Reach III, however, residual or continuing damages would be experienced with such relative frequency that this alternative cannot in good faith be recommended as being in the Federal interest.

The project sponsor, the City and County of San Francisco has stated that they do not have the funding at this time to pursue the one identified alternative which is both economically justified and acceptable to the National Park Service and have requested that the study be terminated and a wrap-up report prepared to record the results of the study effort by the Corps, the City and others. This report was prepared with that request in mind.

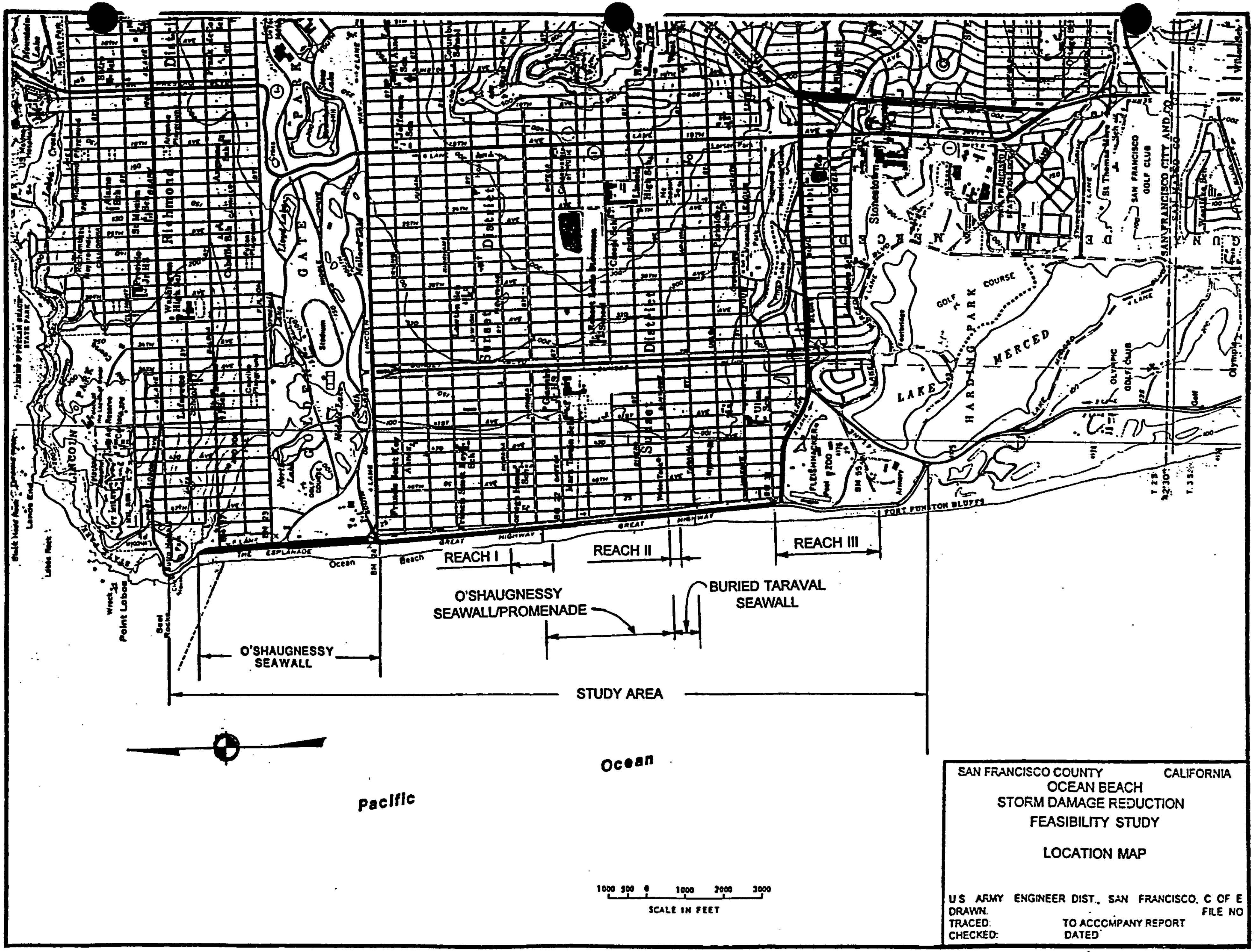
21. RECOMMENDATIONS

Because the local sponsor has not demonstrated an intent to participate as a cost-sharing partner during further feasibility and subsequent project construction phases, our recommendation is to terminate the San Francisco Ocean Beach, San Francisco County, California, General Investigation Study.

Prior to transmittal to the Congress, the sponsor, the State, interested Federal Agencies, and other parties will be afforded an opportunity to comment on this recommendation.

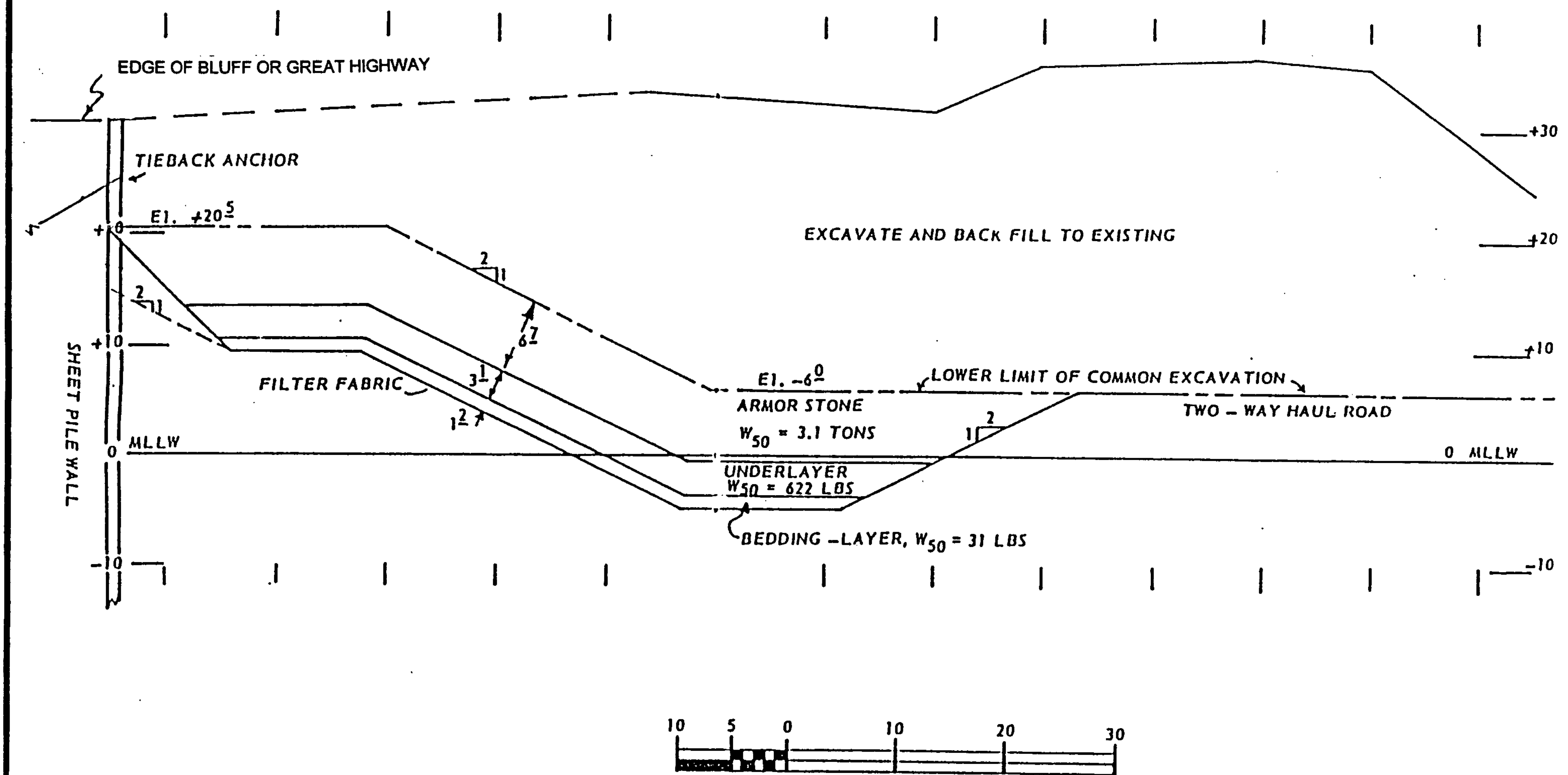
Date: 24 SEP 96

RICHARD G. THOMPSON
Lieutenant Colonel, Corps of Engineers
District Engineer



SAN FRANCISCO COUNTY	CALIFORNIA
OCEAN BEACH STORM DAMAGE REDUCTION FEASIBILITY STUDY	
LOCATION MAP	
US ARMY ENGINEER DIST., SAN FRANCISCO. C OF E	
DRAWN.	FILE NO
TRACED:	TO ACCOMPANY REPORT
CHECKED:	DATED

FIGURE 1



SAN FRANCISCO COUNTY CALIFORNIA
OCEAN BEACH
STORM DAMAGE REDUCTION
RECONNAISSANCE STUDY
REVETMENT ALTERNATIVE

TYPICAL CROSS-SECTION OF
RUBBLE MOUND REVETMENT REACH III

U S ARMY ENGINEER DIST. SAN FRANCISCO, C OF E
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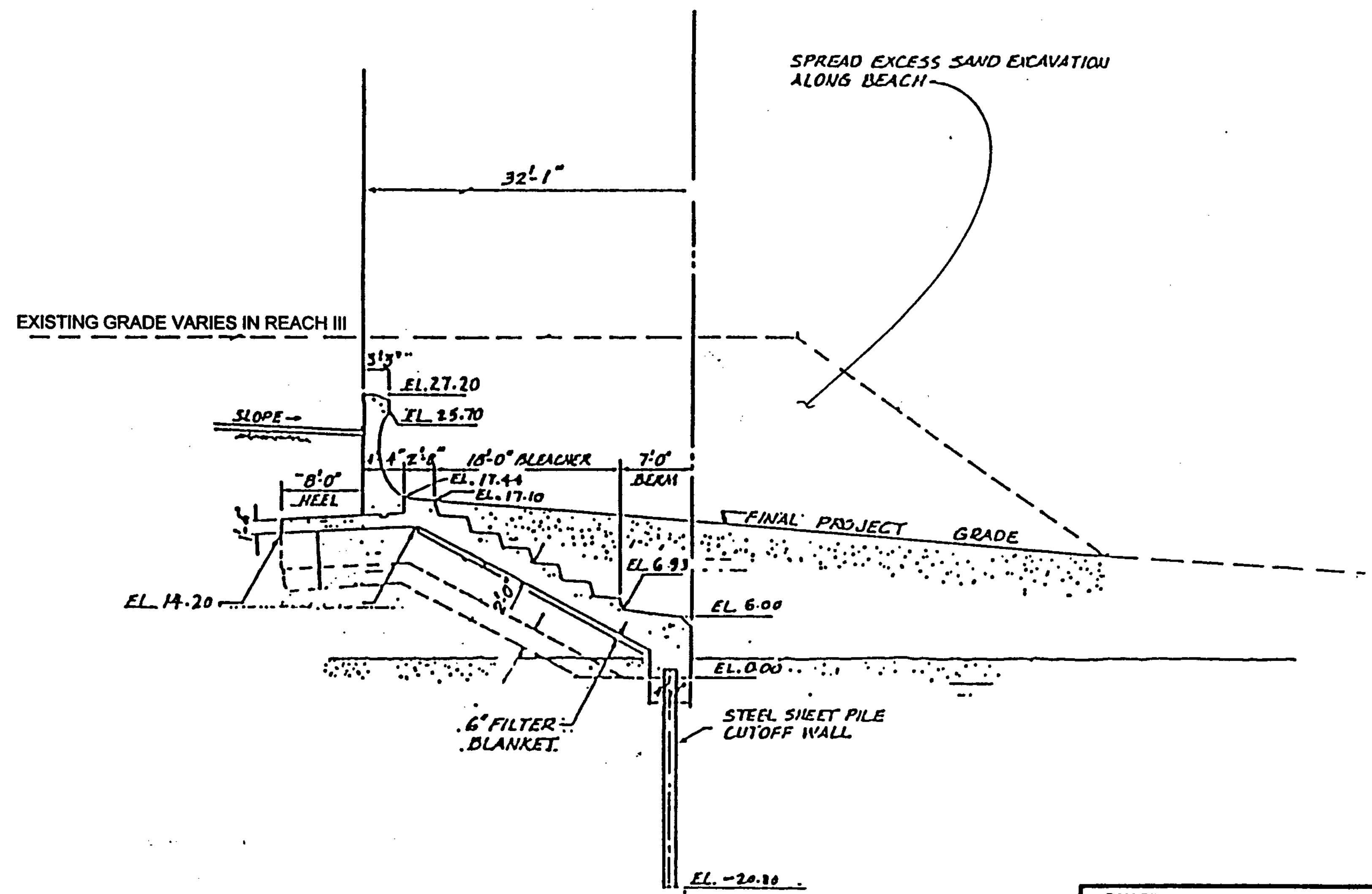
FIGURE 2



SAN FRANCISCO COUNTY CALIFORNIA
OCEAN BEACH
STORM DAMAGE REDUCTION
RECONNAISSANCE STUDY
SEAWALL ALTERNATIVE

TYPICAL CROSS SECTION OF
O'SHAUGHNESSY TYPE SEAWALL REACH III

U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
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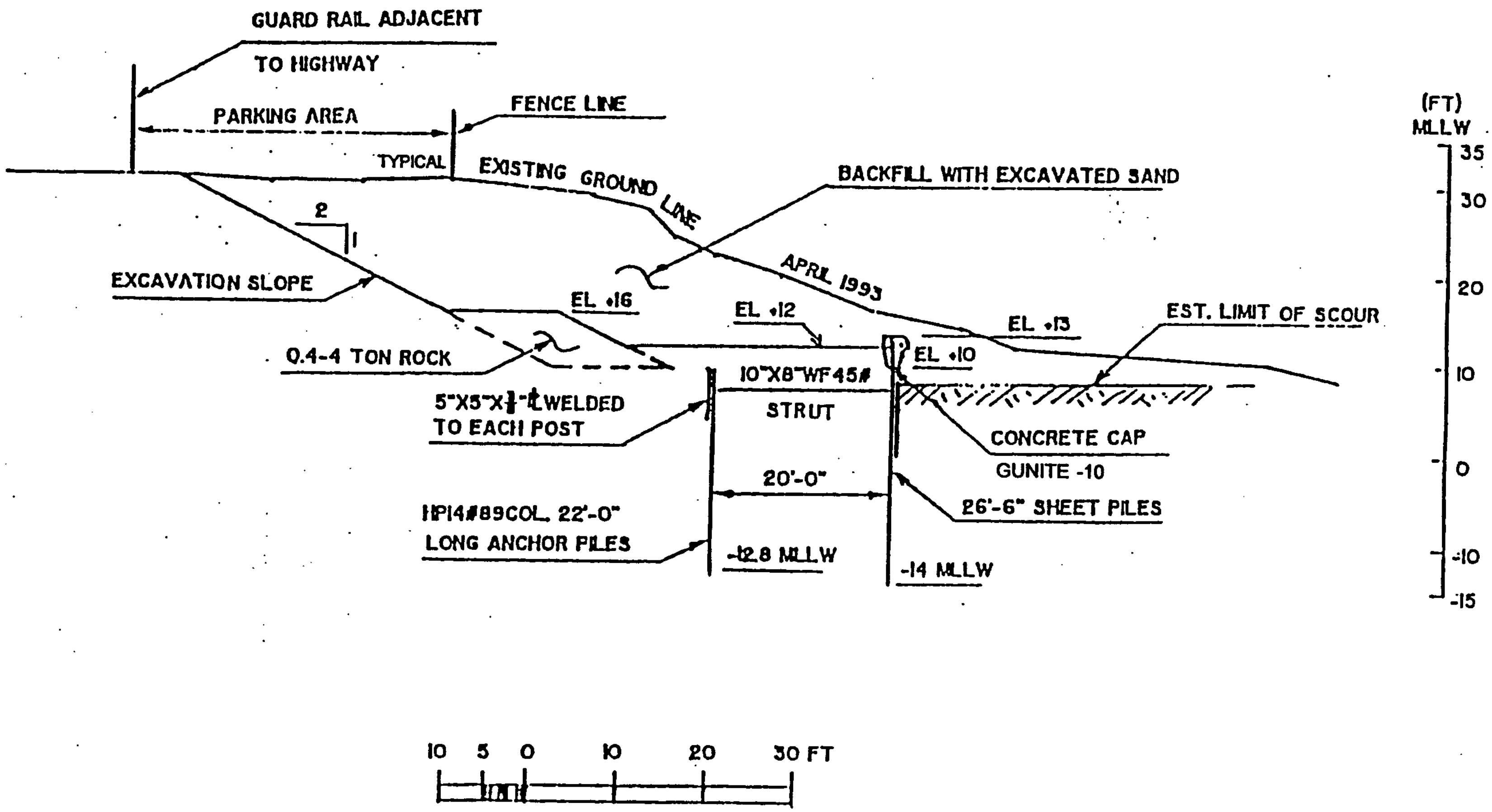
FIGURE 3



SAN FRANCISCO COUNTY CALIFORNIA
OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

TARAVAL TYPE WALL CROSS SECTION
REACH III MIDDLE PARKING LOT

U S ARMY ENGINEER DIST, SAN FRANCISCO, C OF E
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FIGURE 4

ATTACHMENT - A

VIEWS OF
SPONSOR
AND
NATIONAL PARK SERVICE

City and County of San Francisco

Department of Public Works
Project Management

May 1, 1996

Mr. Arijs Rakstins
Project Manager
U.S. Army Corps of Engineers
San Francisco District
211 Main Street, Suite 905
San Francisco, CA 94105

Dear Mr. Rakstins:

Based on the outcome of meetings held this year with the California Coastal Commission (CCC), Golden Gate National Recreational Area (GGNRA) and your agency, the City and County of San Francisco, Department of Public Works authorizes the Corps of Engineers to prepare a wrap-up report for the Ocean Beach Study.

At this time the City does not have the funding to pursue the buried seawall alternative, however, the City reserves the right to investigate a seawall alternative with the Corps of Engineers (COE) in the future. In the event that a seawall is constructed in the future along the reach south of Sloat, the Federal/Local partnership for design and construction would be pursued by the City.

The COE wrap-up report should highlight all work done (by COE and others) to date, as well as the positive findings for Reaches 1 and 2. Complete analysis of the findings presented in the Moffatt and Nichol Engineering Report regarding "no net loss of sand to the beach" should be included. Prior to start of work on this document please develop a schedule and budget. During this final phase monthly progress meetings are requested.

The City will be developing an emergency plan to address the areas of extreme erosion and will be hiring a coastal engineering consultant to evaluate reinforcement for areas of the beach south of Sloat.

Thank you for your assistance, if you have any questions please call me at 558-4026.

Sincerely yours,

Karen Kubick

Karen Kubick
Project Manager

30 VAN NESS AVENUE, SAN FRANCISCO, CA (415) 558-4000 / FAX (415) 558-4519

< THIS LETTER RECEIVED VIA E-MAIL FROM NANCY HORNER OF THE >
< NATIONAL PARK SERVICE (NPS) ON OCTOBER 19, 1995 @ 3:43 PM. >

D18(GOGA-RMPPC)

William Angeloni
Chief, Planning and Engineering Division
Hydraulic/Coastal Section
San Francisco District
Corps of Engineers
211 Main Street
San Francisco, California 94105-1905

Dear Mr. Angeloni:

My staff met with representatives of the San Francisco District, Army Corps of Engineers on September 21, 1995 to discuss the Ocean Beach Feasibility Study and the options for reach 3, which has been determined by the Corps to be the only reach where action is economically justified at this time.

We learned at that meeting that the analysis shows that from the Cliff House to Sloat Boulevard the potential for erosion damage is not as great as was previously anticipated. In reach 3, the dune nourishment alternative is not recommended by the Corps, because it is not a permanent solution, and damage would frequently occur. We also discussed the three structural solutions previously identified.

Dune nourishment would be done one time only as part of a structural solution, but is not recommended by the Corps as a long term maintenance strategy.

Based on the Corps models using 1993 topography, your staff predicts that a Taraval type seawall, 2700 feet long, in reach 3 would be exposed for 1/2 of its length, 6-12'deep every 1-2 winters. The northern 1/2 would be exposed every 5-10 years for up to 4 months. The Corps does not feel that over time the shoreline would move eastward causing longer duration of exposure. According to your staff, the best estimate is that the shoreline will remain where it is, rather than recede as a result of sea level rise or other long term trends. The erosion damage prediction is based on storm events, which could cause a loss of 40-60 feet in one year.

In response to this information and technical assistance offered by the National Biological Service, we have the following comments:

1. NPS policy emphasizes avoidance of hard structures and interference with natural processes.

2. We feel that a hard structure will eventually result in loss of beach, which is the prime recreational resource, and may affect the adjacent bluffs which are habitat for a threatened species, the state-listed bank swallow.

3. We promote non-structural solutions in the Ocean Beach corridor.

4. If structural solutions are necessary to protect the City's investments in infrastructure, their implementation should be delayed as long as possible.

5. We would be willing to lose all or part of the investment in parking lots/restroom to retain the beach longer and avoid structural solutions as long as possible.

6. We would support a "non-aggressive" approach to structural solutions to protect the City's investment. The City and Corps should identify a "trigger point" in time or location where a seawall needs to be built to adequately protect the City's investment. We would consider construction of a seawall on National Park Service land, constructed as far east as possible to prolong the life of the beach. If the seawall would protect the parking lots/restroom we would not object, but would otherwise be working with the City and County of San Francisco to identify alternative locations for parking and restrooms, where they would not be threatened by erosion and storm damage.

7. A one time placement of sand as a nourishment strategy is not acceptable. A program of periodic dune nourishment should be part of any structural solution. Periodic dune nourishment would ensure that a Taraval-type seawall would stay buried to a far greater degree than if the active beach were allowed to respond to the wave/storm climate alone. Keeping the wall buried would also improve the safety and aesthetics of the site after seawall construction. Dune nourishment should be timed to minimize impacts to visitors and aesthetics as well as natural resource values.

8. We believe that if a structural solution is implemented, a Taraval type seawall is preferred over the other proposed methods. Because this type of seawall would remain buried during much of the year initially, it would preserve the natural appearance of the beach to a much greater extent than an O'Shaunnessy type seawall.

9. The National Park Service would not permit construction of a rubble mound revetment on park lands for several reasons including safety considerations, rodent problems, visual impact, maintenance requirements (both in cost and disruption

to visitors and wildlife), and because this method would require a greater portion of the useable beach. This type of solution is not appropriate in the recreational setting of Ocean Beach. A rubble mound revetment should be eliminated from further consideration, even if it would be built entirely on City property.

The environmental document that would be prepared for this project should fully address natural, cultural scenic and recreation resources that would be affected by the proposed project, including submerged cultural resources, and the federally listed snowy plover which is present at Ocean Beach during the non-breeding season. We look forward to continuing discussions with your agency regarding this project.

Sincerely,

Brian O'Neill
General Superintendent

cc: Dr. Stephen Cofer-Shabica, National Biological Service
Dr. Judd Howell, National Biological Service
Dave Jones, SF-DPW

ATTACHMENT B

COST ESTIMATES FOR
HARD STRUCTURE ALTERNATIVES
FOR REACH III

TABLE 1
OCEAN BEACH STORM DAMAGE REDUCTION STUDY
COST ESTIMATE SUMMARY

O'SHAUGHNESSY TYPE SEAWALL ALTERNATIVE
REACH 3 - 2,680 LINEAL FEET

Construction First Cost

Item	Description	Quantity	Unit	Unit Cost	
1.	Mob & Demob	1	Job	L.S.	$100,000
2.	Dewatering	1	Job	L.S.	$409,000
3.	Clearing and Grubbing	18.6	Acre	$500	$9,300
4.	Excavation				
	Above Common Line	307,400	CY	$3.90	$1,198,860
	Seawall Excavation	56,685	CY	$3.90	$221,072
	Access Haul Road	82,772	CY	$3.90	$322,811
5.	Backfill				
	Above Common Line	107691	CY	$5.75	$619,223
	Seawall Excavation	49,986	CY	$5.50	$274,923
	Access Haul Road	82,772	CY	$31.24	$2,585,797
	Excess Waste	219,309	CY	$5.00	$1,096,545
6.	Sheetpile				
	PZ-35	56,410	SF	$14.70	$829,227
	PZ-27	16,733	SF	$14.70	$245,975
	Along Great Highway	152,976	SF	$14.70	$2,248,747
	Tieback	11,416	SF	$45.00	$513,720
7.	Concrete				
	Mob & Demob	1	Job	L.S.	$400,000
	Concrete Seawall	13,000	CY	$440.00	$5,720,000
	Geofabric	161,336	SF	$3.50	$564,676
	Filter Material	3,081	CY	$20.00	$61,620
	Promenade Paving	1	Job	L.S.	$1,092,000
	Ground Water Cut-Off	85,171	SF	$15.00	$1,277,565

SUBTOTAL	$19,791,061
Contingencies (25% +/-)	$4,947,765
Engineering and Design (5% +/-)	$989,553
Supervision and Administration (4% +/-)	$791,642
TOTAL CONSTRUCTION FIRST COST	$26,520,022
REAL ESTATE COST (Right of Way)	$64,000
INTEREST DURING CONSTRUCTION (19 Months)	$1,351,354
TOTAL PROJECT FIRST COST	$27,935,376
Capitol Recovery Factor (7 5/8 % FOR 50 YEARS)	0.07824
Annualized First Cost	$2,185,664
Annual Maintenance (0.5% +/-)	$139,677
AVERAGE ANNUAL COST	$2,325,341

TABLE 2
OCEAN BEACH STORM DAMAGE REDUCTION STUDY
COST ESTIMATE SUMMARY

TARAVAL TYPE SEAWALL
REACH 3 - 2680 LINEAL FEET

Construction First Cost

Item	Description	Quantity	Unit	Unit Cost	Amount
1.	Mob & Demob	1	Job	L.S.	$100,000
2.	Dewatering	1	Job	L.S.	$409,500
3.	Clearing and Grubbing	18.6	Acre	$500	$9,300
4.	Excavation				
	Above Common Line	305,410	CY	$3.90	$1,191,099
	Revetment Section	17,461	CY	$3.90	$68,098
	Access Haul Road	82,772	CY	$3.90	$322,811
5.	Backfill				
	All Excavated Materials	420,533	CY	$3.90	$1,640,079
6.	Rock Placement				
	Armor Stone .5 - 4.0 ton	9,983	CY	$41.63	$415,592
	Bedding Layer (12" Riprap)	3,992	CY	$34.20	$136,526
	Filter Fabric	79,500	SY	$3.50	$278,250
7.	Seawall				
	Sheet Pile Wall	75,000.00	SF	$28.80	$2,160,000
	Steel Wale WF10X61	2,830	LF	$51.20	$144,896
	Steet Struts WF10X45	3,180	LF	$32.30	$102,714
	Steel H-Pile HP14X89	3,498	LF	$34.21	$119,667
	Steel Plates 5'X5'X3/8'	3,975	SF	$46.05	$183,049
	Steel Brackets	318	PCS	$3.40	$1,081
	Shotcrete (6" thick)	19,810.00	SF	$6.80	$134,708
	(or 612 CY including 40% rebound)	1	Job	L.S.	$0
	Concrete Capl	630	CY	$155.30	$97,839
8	Revegetation	44,668	SF	$5.30	$236,740

SUBTOTAL	$7,751,949
Contingencies (25% +/-)	$1,937,987
Engineering and Design (5% +/-)	$387,597
Supervision and Administration (4% +/-)	$310,078
TOTAL CONSTRUCTION FIRST COST	$10,387,612
REAL ESTATE COST (Right of Way)	$59,700
INTEREST DURING CONSTRUCTION (16 Months)	$531,072
TOTAL PROJECT FIRST COST	$10,978,383
Capitol Recovery Factor (7 5/8 % for 50 years)	0.07824
Annualized First Cost	$858,949
Annual Maintenance (0.5% +/-)	$54,892
AVERAGE ANNUAL COST	$913,841

TABLE 3
OCEAN BEACH STORM DAMAGE REDUCTION STUDY
COST ESTIMATE SUMMARY

RUBBLE-MOUND REVETMENT ALTERNATIVE

REACH 3 - 2680 LINEAL FEET

Construction First Cost

Item	Description	Quantity	Unit	Unit Cost	
1.	Mob & Demob	1	Job	L.S.	$100,000
2.	Dewatering	1	Job	L.S.	$409,500
3.	Clearing and Grubbing	18.6	Acre	$500	$9,300
4.	Excavation				
	Above Common Line	320,313	CY	$3.90	$1,249,221
	Revetment Section	91,830	CY	$3.90	$358,137
	Sand Wedge	3,081	CY	$3.90	$12,016
	Access Haul Road	82,775	CY	$3.90	$322,823
5.	Backfill				
	Above Revetment	320,313	CY	$3.90	$1,249,221
	Revetment Section	20,609	CY	$5.50	$113,350
	Sand Wedge	3,081		$5.50	$16,946
	Access Haul Road	82,775	CY	$31.24	$2,585,891
6.	Sheetpile				
	Along Great Highway	152,983	SF	$14.70	$2,248,850
	Tieback	11,416	Lf	$45.00	$513,720
7.	Rock Placement				
	Armor Stone 2.3-4.0 ton	85,454	Ton	$41.63	$3,557,450
	Under Layer	32,346	Ton	$39.34	$1,272,492
	Bedding Layer	12,200	Ton	$34.20	$417,240
	Filter Fabric	42,296	SY	$3.50	$148,036
	Cellular Confinement (for haul road)	324,540	SF	$1.50	$486,810
	Temporary Sheetpile (for groundwater cut-off)	83,174	SF	$15.00	$1,247,610
8.	Revegetation	44,668	SY	$5.30	$236,740
	SUBTOTAL				$16,555,351
	Contingencies (25% +/-)				$4,138,838
	Engineering and Design (5% +/-)				$827,768
	Supervision and Administration (4% +/-)				$662,214
	TOTAL CONSTRUCTION FIRST COST				$22,184,170
	REAL ESTATE COST (Right-of-Way)				$59,700
	INTEREST DURING CONSTRUCTION (16 MONTHS)				$1,260,906
	TOTAL PROJECT FIRST COST				$23,504,776
	Capitol Recovery Factor (7 5/8 % for 50 years)				0.07824
	Annualized First Cost				$1,839,014
	Annual Maintenance (0.5% +/-)				$117,524
	AVERAGE ANNUAL COST				$1,956,538

ATTACHMENT C

LIST OF DOCUMENTS FROM PREVIOUS STUDIES

Other studies in the vicinity of Ocean Beach which were identified in the report for the reconnaissance phase of the current study are listed in Attachment A.

1. Cooper, "Coastal Dunes of California," the Geological Society of America, Memoir 104, 1967.

2. Ecker, R.M., "Ocean Beach Sand Replenishment Program," Towill, Inc., October 1980.

3. Ecker, R.M., "Field Report, Ocean Beach Site Investigation," Battelle, January 1982.

4. Ecker, R.M., "Re-Evaluation of Ocean Beach Sand Replenishment Plan," Battelle, March 1982.

5. Ecker, R.M., "Evaluation of Current Berm Storage Construction on Ocean Beach," Battelle, June 1982.

6. Ecker, R.M., "Site Visit of January Storm Damage, Ocean Beach," Battelle, February 1983.

7. Ecker, R.M., "Evaluation of Storm Damage to San Francisco's Ocean Beach and the Westside Transport Project During the Winter of 1982-1983," Battelle, May 1983.

8. Galvin, Cyrill, "Compilation of Facts Relating to a Coastal Study of Ocean Beach, San Francisco," March 1979.

9. Galvin, Cyril, "Coastal Processes and Sedimentation Budget of Ocean Beach, San Francisco," March 1979.

10. Galvin, Cyril, "Predicted Shorelines at Ocean Beach, San Francisco," April 1979.

11. Galvin, Cyril, "Design Recommendations for Ocean Beach," 1979.

12. Johnson, J.W., "Shoreline Characteristics, Ocean Beach, San Francisco," Consulting Engineer, May 1977.

APPENDIX - A

COASTAL ENGINEERING ANALYSIS

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

SAN FRANCISCO BEACH
(OCEAN BEACH)
SAN FRANCISCO, CALIFORNIA
FEASIBILITY STUDY

APPENDIX A: COASTAL ENGINEERING ANALYSIS

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SAN FRANCISCO BEACH (OCEAN BEACH)
SAN FRANCISCO, CALIFORNIA
FEASIBILITY STUDY

APPENDIX A: COASTAL ENGINEERING ANALYSIS

1. INTRODUCTION

1.1 PURPOSE

The purpose of this study is to assess coastal processes along Ocean Beach, and to evaluate storm damage reduction alternatives for various reaches along the beach.

1.2 SCOPE

The scope of this study involves the review of previous studies that evaluated shoreline characteristics, wave attack, historical beach erosion, and the need for shoreline protection for reaches of Ocean Beach. This study builds upon existing data and develops alternatives for long-term erosion control at Ocean Beach. For this study, the alternatives assessed are limited to: (1) a dune nourishment/replenishment plan; (2) a Taraval-type seawall; and (3) a beach nourishment/replenishment plan.

1.3 LOCATION

Ocean Beach is located south of the entrance to San Francisco Bay and is fixed by a headland on the north end. See the location map on Plate 1. The beach extends from Fort Funston north to the Cliff House, a distance of approximately 3.6 miles.

1.4 BACKGROUND AND PAST REPORTS

In the past, protective structures have been used at several locations to protect the bluffs and the Great Highway from erosion. The 4,300-foot-long O'Shaughnessy Seawall was constructed at the northernmost end of the beach between 1915 and 1922. The Taraval Seawall, between Taraval and Santiago Streets, was constructed in 1941 at the base of the bluffs. Most recently (from 1987 to 1993), the new Great Highway Seawall/Promenade was constructed between Noriega and Santiago Streets.

Additional protective measures, such as dune stabilization, the dumping of sand and broken pavement, and rubble slope armoring have been used when the Great Highway was damaged or threatened. A time line of important events in the history of Ocean beach is listed in Table 1 (Moffatt & Nichol, 1995).

TABLE 1

TIMELINE OF MAN-INDUCED EVENTS AT OCEAN BEACH

1852	The first map showing the natural shoreline according to Olmsted and Olmsted is the 1852 United States Coastal Survey. This map shows Ocean Beach as unaltered by human Intervention (Olmsted and Olmsted, 1979).
1868	Fences were constructed above HWL to help create more dunes.
1872 - 1882	Dune stabilization and road improvements were completed north of Lincoln.
1882	Shoreline was 150' - 200' seaward of 1852 position north of Lawton due to dune, road and beach improvements. Shoreline was unchanged from 1852 south of Lawton.
1882 - 1884	Fence was constructed from Fulton to Moraga.
1884	A fence was built extending southward from Fulton Street to Moraga Street. The fence was built to stabilize the dune that the new great Highway would be built on (Olmsted and Olmsted, 1979).
1890 - 1900	Road improvements, including road widening and the placing of fill on the northern end of Ocean Beach, were taking place. One of the largest additions of sand to Ocean Beach was the partial filling of the outlet to Lake Merced (at approximately Sloat Blvd.). This fill provided a stable base for continuing the Great Highway farther down the beach. Also dune building was taking place in the 1890's on the north end of the beach to protect buildings and the highway. Sand was also placed on troubled dune areas to protect the Great Highway (Olmsted and Olmsted, 1979).
1907	A wooden bulkhead was built to protect structures on the north end of Ocean Beach (Olmsted and Olmsted, 1979).
1912	During October there was a large storm from the northwest (Griggs, 1987).
1915	During this year the first paving of the improved Great Highway-South had taken place. This was accomplished by paving over the narrow natural dune which had been providing the only buffer against the waves. Erosion and crumbling of the Great Highway called for more protection from the waves, especially at the north end. Construction for the O'Shaughnessy Seawall begin in 1915. The seawall would be constructed as follows "Interlocking sheetpiles of reinforced concrete formed a tight cutoff wall at the lower edge. The inshore edge and wall were

supported on, and anchored by, reinforced concrete pedestal piles, 10 feet apart, along the structures. Cross cut-off of sheet-piling were placed at 150 feet apart in the event of progressive destruction; that is, if one section should be undermined the whole would not collapse" (Olmsted and Olmsted, 1979).

1915 - 1927 980,000 cubic yards of sand were placed on all of Ocean Beach (USACE, 1979).

1922 San Francisco Bar channel was dredged to -40 feet MLLW (USACE, 1990).

1923 During the 29th of November to the 1st of December a "northwest gale" hit the northern California Coast (Griggs, 1987).

1924 The construction of twenty two timber pile groins took place along Fort Funston Beach to protect the toe of the cliffs from wave erosion. Within three years mostly all of the groins had been removed by the wave action (USACE, 1979).

1927 - 1929 The O'Shaughnessy Seawall was completed. Construction of the improved Great Highway also took place during this time. 1,260,000 cubic yards of sand was placed along the length of Ocean Beach creating a dune 200 feet wide and a top elevation of 30-32 feet above MLLW (USACE, 1992). This sand placement extended the dune westward and seaward, to accommodate the construction of a divided eight lane highway. This artificial extension of the dune was followed by accelerated erosion, in 1931, of the dune and Great Highway (USACE, 1979).

1931 On February 20, a gale intensity storm hit the northern California coast.

1931 1,554,000 cubic yards were dredged from San Francisco Bar (USACE, 1990).

1931 - 1935 140,000 cubic yards of sand placed on beach as fill between Lincoln and Taraval (USACE, 1992).

1932 During December, a northwest storm hit the northern California coast.

1932 - 1934 San Francisco Bar Channel deepened to -45 feet MLLW (USACE, 1990), as follows:
1932 - 1,329,000 cubic yards were dredged;
1933 - 1,284,000 cubic yards were dredged;
1934 - 2,542,000 cubic yards were dredged;

1935 948,000 cubic yards were dredged from San Francisco Bar (USACE, 1990)

1936 1,365,000 cubic yards were dredged from San Francisco Bar (USACE, 1990)

1939 In December, high waves and high tides combined to create storm damage along the northern California coast (Griggs, 1987).

1930 - 1941 A pedestrian underpass was constructed at Judah and Taraval streets in 1930. In 1931 the Taraval underpass was severely damaged by a winter storm. Shortly after that, a wooden bulkhead was built in front of, and a whole ways to the north and south, of the underpass. In 1939 the bulkhead was badly damaged by another winter storm and in 1941, it was replaced by a new bulkhead, "The Taraval Seawall" constructed of "steel sheet piling with a reinforced concrete cap" (Olmsted and Olmsted, 1979).

1935 - 1941 Estimated loss of 790,000 cubic yards of sand (USACE, 1992).

1941 55,000 cubic yards were dredged from San Francisco Bar (USACE, 1990).

1942 In December, a northwest storm hit the northern California coast (Griggs, 1987).

1942 - 1943 A portion of San Francisco Bar Channel deepened to -50 feet MLLW (USACE, 1990), as follows:

1942 - 888,000 cubic yards were dredged;
1943 - 1,100,000 cubic yards were dredged;

1942 - 1946 Fill at Rivera and Ulloa moved shore seaward 40 feet (USACE, 1992).

1943 - 1948 Severe storms from the north and northwest hit the northern California coast during the winter and early spring months (Griggs, 1987).

1950 During October, a severe storm with northerly gale winds and gigantic waves hit the northern California coast.

1950 697,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).

1951 5,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).

1952 410,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).

1953 In February, a northwest gale hit the northern California coast (Griggs, 1987).

1953 1,004,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).

1953 - 1963	An unknown quantity of sand was mined from Ocean Beach (USACE, 1992).
1954	245,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).
1955	1,429,500 cubic yards were dredged from San Francisco Bar Channel (Johnson, 1965).
1956	309,000 cubic yards were dredged from San Francisco Bar Channel (Johnson, 1965).
1957	595,000 cubic yards were dredged from San Francisco Bar Channel (Johnson, 1965).
1958	626,000 cubic yards were dredged from San Francisco Bar Channel (Johnson, 1965).
1959	3,840,000 cubic yards were dredged from San Francisco Bar (Johnson, 1965). (Channel deepening to 50 feet deep, 2000 feet wide completed, deepening volume 1,375,000 cubic yards, USACE, 1990).
1960	763,000 cubic yards were dredged from San Francisco Bar (Johnson, 1965).
1961	875,000 cubic yards were dredged from San Francisco Bar (Johnson, 1965).
1962	1,145,000 cubic yards were dredged from San Francisco Bar (Johnson, 1965).
1963	842,000 cubic yards were dredged from San Francisco Bar (Johnson, 1965).
1964	581,000 cubic yards were dredged from San Francisco Bar (Johnson, 1965).
1965	669,000 cubic yards were dredged from San Francisco Bar (Johnson, 1965).
1966	412,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).
1967	433,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).
1968	476,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).
1969	661,000 cubic yards were dredged from San Francisco Bar Channel (USACE,

	1990).
1970	204,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).
1971	Dredged sediment from Bar Channel disposed on Bar about 6000 feet south of and parallel to channel. Prior disposal approximately 1 mile southwest of channel entrance (USACE June 1974).
1971	1,048,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).
1972	603,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).
1972	On the southern end of Ocean Beach, ice plant and grasses were planted on the dune and concrete blocks and rubble were placed in from of the dunes for the purpose of mitigating erosion (USACE, 1992).
1973	740,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).
1974	639,000 cubic yards were dredged from San Francisco Bar Channel (USACE, 1990).
1972 - 1975	San Francisco Bar Channel deepened to -55 feet MLLW (USACE, 1990), as follows: 1972 - 1,355,000 cubic yards were dredged; 1973 - 1,347,000 cubic yards were dredged; 1974 - 1,632,000 cubic yards were dredged; 1975 - 1,430,900 cubic yards were dredged;
1963 - 1967	100,000 cubic yards of sand was mined from Ocean Beach (USACE, 1992).
1967	Sand mining was terminated (USACE, 1992).
Early 1970's	In the early 1970's fill was placed south of Sloat for the extension of the Great Highway (USACE, 1992).
1976	887,254 cubic yards were dredged from San Francisco Bar (USACE, 1995).
1976	The City of San Francisco began to place wind blown sand from the Great Highway and seawall back on the beach (USACE, 1992).

1977	310,000 cubic yards were dredged from San Francisco Bar (USACE, 1995).
1978	During the winter of 1978, winter storms hit the whole of the California coastline. These storms had the greatest effect on west and southwest facing beaches (Griggs, 1987).
1978	761,000 cubic yards were dredged from San Francisco Bar (USACE, 1995).
1979	843,500 cubic yards were dredged from San Francisco Bar (USACE, 1995).
1980	778,635 cubic yards were dredged from San Francisco Bar (USACE, 1995).\
1980 - 1981	The Westside Sewage Transport Box construction started. 600,000 cubic yards of excavated sand were placed on the beach in the form of dune nourishment (USACE, 1992).
1982	915,816 cubic yards were dredged from San Francisco Bar (USACE, 1995).
1982 - 1983	During the winter months, severe El Niño storm hit the whole of the California coast (Griggs, 1987).
1982 - 1983	A heavy El Niño storm eroded up to 70% of 1980 - 1981 sand placement. At Pacheco and Quintara, 60 feet of dune was eroded (USACE, 1992). Certain areas of the beach were eroded down to bedrock and toward the south end of the study area the wooden hull of an old shipwreck was exposed. Revetment was added to these areas to protect the detour road for construction of the transport box (USACE, 1992).
1983	635,500 cubic yards were dredged from San Francisco Bar (USACE, 1995).
1984	The Great Highway was undercut and damaged by storms (USACE, 1992).
1984	77,969 cubic yards were dredged from San Francisco Bar (USACE, 1995).
1985	Sand Fencing was erected and dune grass was planted for the dune stabilization areas south of Lincoln Way (USACE, 1992).
1985	890,550 cubic yards were dredged from San Francisco Bar (USACE, 1995).
1986	Winter storms and spring tides hit the northern California coast (Griggs, 1987).
1986	903,200 cubic yards were dredged from San Francisco Bar (USACE, 1995).

1987 686,159 cubic yards were dredged from San Francisco Bar (USACE, 1995).

1986 - 1993 Sand was excavated for the Great Highway Seawall footings; 100,000 cubic yards of sand was placed on beach between 1986 - 1989 and 250,000 cubic yards between 1989 - 1992. Seawall construction began in 1987 and was constructed in 3 phases. The seawall was completed in August 1993. It extends from south of Noriega Street to Santiago Street (USACE, 1992). Dunes fronting seawall (Noriega to Santiago) were pushed on to beach, and subsequently moved by wave action. Some of the dune material was possibly trucked to the area south of Sloat Blvd.

1988 667,650 cubic yards were dredged from San Francisco Bar (USACE, 1995).

1989 198,150 cubic yards were dredged from San Francisco Bar (USACE, 1995).

1990 524,150 cubic yards were dredged from San Francisco Bar (USACE, 1995).

1991 272,287 cubic yards were dredged from San Francisco Bar (USACE, 1995).

1992 441,870 cubic yards were dredged from San Francisco Bar (USACE, 1995).

1993 417,672 cubic yards were dredged from San Francisco Bar (USACE, 1995).

1994 886,588 cubic yards were dredged from San Francisco Bar (USACE, 1995).

1994 35,000 cubic yards of wind deposited sand were moved from in front of the new seawall between Noriega and Santiago Streets. 10,000 cubic yards were placed up to 200 feet north and 200 feet south of the new seawall and spread on the beach. 25,000 cubic yards were placed, at a 3:1 slope, in front of South parking lot, south of Sloat Blvd.

2. PHYSICAL SETTING

2.1 GEOMORPHIC AND GEOLOGIC SETTING

The study area lies on the western shore of the San Francisco Peninsula, south of Golden Gate Park and north of Fort Funston. The San Francisco Peninsula is formed by the northern end of the Santa Cruz Mountains and lies within the Coast Range physiographic province of California. The stratigraphy consist of, from youngest to oldest, placed fill, dune sands, Colma Formation, Merced Formation, and bedrock. Each of the stratigraphic units will be briefly described in the following paragraphs.

The placed fill comprises a part of the surface soil deposits. The fill is mainly reworked dune sands placed during the construction of the Great Highway in 1920's and again during its relocation in 1988 - 1989. The Great Highway was relocated as a result of the construction of the Great Highway Seawall/Promenade and the Westside Outfall Sewer Transport Pipe. Subsurface investigation in 1985, prior to the construction of the Great Highway Seawall/Promenade, indicated that the placed fill in the northern reach of the study area was 10 to 12 feet thick; in the middle reach, 7 to 14 feet thick; and 16 feet thick at Wawona Street. South of Sloat Boulevard there is no known data on the thickness of placed fill.

The sand dunes are composed of windblown sand, fine to medium grained and poorly graded. The source of the dune sand is from Ocean Beach. The sand from the beach is generally yellowish brown to light gray and speckled with a few white shell fragments and abundant dark-gray, green, and brown grains. The sand dunes are primarily of Holocene to recent in age, although they may extend into very late Pleistocene time. A subsurface exploration program conducted by Allstate Geotechnical Services (1985) indicated that the dune sand in the northern reach of the study area may range in thickness from 16 to 20 feet. The thickness of dune sand in the middle reach may range from 20 to 26.5 feet. At Wawona Street the thickness of dune sand is 13 feet. South of Sloat Blvd. the thickness of dune sand may be even greater. According to the Allstate report, a washout occurred through the dune field in 1852 in the vicinity of Fleishacker Zoo and Sloat Blvd. from unusually high water levels in Lake Merced. The washout, probably due to the sudden outpouring of flood water from Lake Merced, deepened the pre-existing outlet and extended it to the ocean. The washout was later filled by dune sand deposits during the period between 1852 and 1906. The Allstate report indicated that an approximate location of the washout was able to be determined from topographic maps. The dunes are underlain by the Coma Formation; the contact is generally above 0.0 feet mean lower low water (MLLW). The exploration program did not extend into the southern reach.

The Colma Formation consists of coastal and estuarine deposits composed predominantly of sand. According to Schlocker (1974): "The Coma Formation appears to have been deposited mostly by water and gravity, and to a lesser extent, by wind in a variety of coastal environments." The Coma Formation was deposited probably during the late Pleistocene, perhaps during the Sangamon Interglacial Stage, the last period of very high sea level stands prior to the Holocene. The Colma Formation occurs both beneath the dune sands and inland at elevations up to about 550 feet MLLW. The Colma has probably experienced some tectonic uplift after being deposited. It is predominantly a poorly graded, fine to medium grained, friable sand deposit with small to moderate amounts of silt and clay. Beds and lenses of silty clay to clayey sand up to 12 feet in thickness were found during the 1985 subsurface investigation both to the north and south of the northern reach and south of the middle reach. At Wawona Street a 3-foot-thick layer of dark brown, very stiff peat was found near the top of the Colma Formation. The Colma Formation is generally light brown to orange in color and has horizontal or nearly horizontal bedding and cross bedding. The beds range from 1 inch to 3 inches thick (Schlocker, 1974). The Colma Formation is considered to be one of the sources of sand to Ocean Beach and thus to the sand dunes. It overlies the Merced Formation; however, due to the lack of deep

borings at the site the depth to the Colma-Merced contact is not known. The Colma Formation is believed to have been deposited on the eroded surface of Merced Formation.

The Merced Formation consists of poorly cemented sand of Pliocene to early Pleistocene age. The Merced Formation is composed of sand grains of similar size and mineralogical content as the Colma Formation; it is considered to be the most likely source of much of the Colma Formation (M.G. Bonilla, oral communication, 1961, in Schlocker, 1974, page 71). The Merced Formation is believed to uncomfortably overlie bedrock of the Jurassic to late Cretaceous Franciscan Complex. Although no borings have been drilled to bedrock in the study area, the depth to bedrock is believed to be in the range of 350 to 450 feet, based upon bedrock-surface maps of Julius Schlocker (1961) and M.G. Bonilla (1964).

2.2 BATHYMETRY

The bathymetry in the vicinity of Ocean Beach can be broken into three bands. The first band, from shore to approximately -30 feet mean lower low water (MLLW), consists of typical nearshore bathymetry. During the summer months there is generally a wide beach berm, steep foreshore, and a barless profile. During the winter months there is generally a narrow beach berm, mild sloping foreshore and a single to multiple barred profile. This band may be considered the predominant breaker zone and is approximately two to three thousand feet in width.

The second band of bathymetry, from the -30 foot contour to the -60 foot contour, which extends out 7 miles at its widest point to 2 miles at its narrowest point, is dominated by the San Francisco Bay ebb tidal bar (see Plate 2). The ebb tidal bar is U-Shaped with the open end of the U, which is approximately 6 miles wide, encompassing the entrance to the bay. The ebb tidal bar extends approximately 5 miles into the ocean. The Mainship channel runs along the centerline of the ebb tidal bar and it is dredged through the top of the U. The crest of the bar varies in depth from -23 feet MLLW on the north lobe at Potato Beach Shoal to -50 feet MLLW in the Mainship Channel to -36 feet MLLW along the southern lobe. The southern lobe of the bar ties into Ocean Beach and Taraval Street and is just over a mile in width at the -36 foot MLLW contour.

The third band of bathymetry, from -60 to -600 MLLW, extends approximately 35 miles offshore to the continental shelf. Significant features in this reach include the Farallon Island and Cordell Bank (see Plate 3).

2.3 SAN FRANCISCO LITTORAL CELL

Ocean Beach is within The San Francisco Littoral Cell, (see Plate 4), a cell that includes the ebb and flood bars of San Francisco Bay, the tidal exchange through the Golden Gate, the sandy waterfront on the north side of San Francisco and possibly the beaches south to Pacifica. The next flux of sand at the north and south boundaries of Ocean Beach is probably small relative to the on/offshore and alongshore exchange in the immediate vicinity of Ocean Beach

and the San Francisco Bar. Further, net alongshore transport at Ocean Beach on an average annual or longer term basis is probably small relative to gross alongshore and on/off shore exchange (Moffatt & Nichol, 1995).

3. CLIMATE

3.1 GENERAL CONDITIONS

The costal climate from San Francisco Bay to Santa Barbara can be described by the Köppen system as "Csb'. The 'C' represents a temperate climate with the average temperature of the coldest month between 27°F and 64°F and the warmest month is not below 50°F. The 's' represents a dry summer season and 'b' represents the median temperature within 'C'.

3.2 STORMS & PRESSURE SYSTEMS

Storms affecting the study area are generated by three basic meteorological phenomena: northern Pacific extra-tropical cyclones, eastern north Pacific tropical cyclones, and extra-tropical storms in the southern hemisphere.

Extra-tropical cyclones regularly form in the north Pacific from October through May. These storms usually track across the Pacific in an easterly direction, and have been responsible for the largest waves incident to the area. The sever wave climate during the 1982-1983 winter storm season was caused by a series of extra-tropical cyclones, which resulted in widespread destruction along the coast of California.

Tropical storms or tropical cyclones develop off the west coast of Mexico during May through November. The tropical cyclones usually track west to northwest, but have been known to veer to various directions. An average of 8 to 9 tropical cyclones per year reach hurricane strength in the eastern north Pacific, however, when the hurricanes reach the cooler waters they weaken and dissipate.

During winter in the southern hemisphere, large intense low pressure systems move from west to east across the ocean between Australia and Chile. Locally these storms can generate very large waves. For the most part this activity occurs from May to October. It has been proposed that their frequency of occurrence is bi-modal, with peaks in the early and late northern hemisphere summer. These waves travel northward across the equator and into the California area. Wave periods are typically long, 16 to 22 seconds, while wave heights reaching California are typically small.

3.3 PRECIPITATION AND FOG

Average annual rainfall is in the neighborhood of 20 inches per year, the bulk of which occurs between November and April.

Warm moist air moving across the cooler water condenses to form fog. Advection fog is most common along the coast during the summer months but does occur at other times of the year. Both true fog, fog that touches the ground, and lifted fog can occur.

3.4 WINDS

Shear stress from winds on the ocean surface generates wave as well as adds to the storm surge along the coast. Wind blown sand is also a concern at Ocean Beach. A compilation of wind speed, percent occurrence, and direction for the Ocean Beach area was extracted from an earlier Corps report (Beach Erosion Control Study, 1979). These data were summarized for the period between 1946 and 1958 at South East Farallon Island. Plate 5 shows the annual wind rose and wind speed for Ocean Beach. Winds from the Northwest dominate the record. Approximately 20% of the recorded wind speeds equaled or exceed 15 mph.

4. OCEANOGRAPHY

4.1 WATER LEVELS

Water level variation along the shoreline is due principally to astronomical tides (i.e. tides driven by the moon, sun and planets); storm surge driven by spatial variation in barometric pressure, wind and wave setup; and inter-annual large scale oscillations in the circular and temperature distribution of the Pacific, commonly referred to as El Niño Southern Oscillation (ENSO). The contribution of other components to water levels are more random in occurrence, although not entirely independent, and more variable both spatially and temporally (USACE, 1994).

Flick (1991) stated that storm surge rarely contributed more than 3 feet to the water level, with the average contribution being more on the order of 1 foot. Seasonal factors such as heating and cooling and atmospheric pressure variation are thought to account for a variation in water level of 0.3 foot to 0.5 foot. Additionally, the El Niño Southern Oscillation, which occurs approximately every four years, can increase water levels another 0.5 foot during extreme events.

Wave setup and setdown along the beach profile varies from a minimum near the wave breaker location and a maximum at the shoreline. Linear wave theory predicts maximum setdown of about 4 to 5 percent of wave height along a plane beach and a slightly higher setup.

Long term changes in sea level due to the "greenhouse" effect, tectonic forces and other

localized ground movement are relatively small. The National Research Council (Marine Board, 1987) considered three plausible future sea level rise scenarios along the coastline of North America: 0.5 m, 1.0 m, 1.5 m by the year 2100 relative to 1986 (USACE, 1994).

According to Flick (1991), a review of monthly mean sea level data recorded at San Francisco indicated that a rise of 0.6 foot per century has occurred. If past trends are projected into the future at San Francisco, a sea level rise of at least 0.3 foot can be expected over the next 50 years.

4.1.1 Tides

The tidal reference for this study is located at the Presidio of San Francisco, approximately six miles north of the study area. The tides along the California Coast are mixed semi-diurnal. Tidal data and prediction for this and other stations can be found in National Oceanographic and Atmospheric Administration (NOAA) publications. Tidal data for the study area are presented in Table 2.

TABLE 2

TIDAL DATA - PRESIDIO STATION		
Highest Recorded Water (1/27/83)	8.9 feet	(MLLW)
Mean Higher High Water (MHHW)	5.8 feet	"
Mean High Water (MHW)	5.2 feet	"
Mean Tide Level (MTL)	3.2 feet	"
Mean Sea Level (MSL)	2.8 feet	"
Mean Low Water (MLW)	1.1 feet	"
Mean Lower Low Water (MLLW)	0.0 feet	"
Lowest Recorded Water (12/17/33)	-2.7 feet	"

4.1.2 Sea Level Rise

Throughout geologic history, global sea level variations (both rise and fall) have occurred. Some authorities have found evidence to indicate we may be entering a new ice age with a resultant sea level drop. Others argue that increasing atmospheric concentrations of carbon dioxide and other gases are causing the earth to warm, thus contributing to a sea level rise. Global cooling or warming trends have at least two consequences: More extensive and

rapid accumulation or melting of snow and ice in alpine and polar areas, and actual contraction or expansion of upper ocean waters. Both consequences contribute to "absolute" global sea level change. The absolute changes cannot be distributed equally due to the dynamic and interactive nature of the earth's atmosphere, oceans, and crust and the changes required thereof by global cooling or warming.

Historical trends are commonly used in hydraulic and hydrological studies to estimate expected future design conditions. High confidence in the predicted values is generally limited to an average return period of not more than three times the length of data record. Local trends in local sea level change can perhaps best indicate what will occur in the future.

Attempting to predict future sea level rise is risky because there are so many variables and, as yet undefined, interrelationships involved. For this reason, hydraulic designers should not make projections as to the degree of either global or relative sea level rise on other than a historic basis. Corps of Engineers policy is that, until substantial evidence indicates otherwise, we will maintain the procedure of considering only local regional history of sea level changes to project a rise or fall for a specific project (USACE, 1986 "Relative Sea Level Change". See Distribution, Directorate of Civil Works).

For this study, 0.6 foot of sea level rise per 100 years will be assumed. This rate has been adopted by the San Francisco District based upon an analysis of historical trends, and is supported by finding by Flick, 1991.

4.1.3 Extreme Water Levels

Extreme water levels are calculated so that the design height of a coastal structure can be determined. In 1984, the Corps of Engineers completed a study of the frequency of tidal stages at stations throughout the Bay. From this report, the 100-year tidal still-water elevation was adopted for the San Francisco tide gage located at the Presidio. In addition, if setup from waves, geographic location, and expected sea level rise are accounted for, a design water level can be determined (Table 3). As shown, the adopted 100-year event water level at Ocean Beach is 12 feet (MLLW).

TABLE 3

ESTIMATED EXTREME WATER LEVELS - OCEAN BEACH 100-YEAR RETURN PERIOD	
Still-Water Level from Historical Data	8.9 feet(MLLW)
Additional Set Up due to Exposed Location	1.0 foot
Expected Sea Level Rise (50 yrs @ 0.6'/100 yrs)	0.3 foot
Wave Set Up	1.5 feet
Total	11.6 feet
Adopted	12.0 feet

4.2 CURRENTS

There are three primary currents types near the coast. These currents are caused by wind, tide, and surf.

4.2.1 Offshore Currents

The California Current, which is present year round, contains waters cooler than those offshore. It travels southward generally at less than half a knot. The current is wind driven but is also impacted by solar heating, upwelling, river discharge, exchange with estuaries and embayments, gravity, and the rotation of the earth.

The Davidson Current is the dominant inshore current from November to February. It runs, northward, inshore of the California Current and carries warmer, more saline water. It is generally a deep water current running in 650 feet of water but does surface when north winds are weak or absent.

4.2.2 Tidal Currents

A tidal wave, also known as a progressive Kelvin edge wave, has its peak crest height at the coast. Water particles in the crest of the tidal wave move in the direction the wave is travelling, while water particles in the trough move in the opposite direction. This flux of water is one of the causes of tidal currents. Another cause of tidal currents in the flux of water in and out of estuaries. This flux through the Golden Gate is the primary cause of currents at Ocean Beach.

Tidal current and height prediction data are published annually by the National

Oceanographic and Atmospheric Administration. Generally, flood currents are to the north along the Ocean Beach shoreline, reaching a maximum velocity of 1.0 knot. Ebb currents are to the south following the shoreline and reach a maximum velocity of 1.3 knots. These currents exclude those currents due to wave action. Surfers in the area have reportedly drifted at speeds reflecting surface current velocities in excess of 1.7 knots.

4.2.3 Surf Driven Currents

For the purpose of this study, wave driven currents are described in two categories, alongshore currents and cross-shore currents.

4.2.3.1 Alongshore Currents

Wave induced alongshore currents are the result of oblique breaking waves incident to the coast. Velocities are most sensitive to the wave angle, while the volume flow rate is controlled by the wave height. Peak velocities, along the cross-shore axis, can be found in or just shoreward of the breaker zone.

At Ocean Beach, tidal currents often dominate wave driven alongshore currents. However, during periods of small tidal changes, wave driven alongshore current can dominate, especially when the waves are short period and arrive at a large angle to shore normal. Also, during large wave events, the concentration of waves at Taraval Street, or the crest of the San Francisco Bar, tends to drive currents away from the bar, that is, northward north of the bar and southward south of the bar.

4.2.3.2. Cross-shore Currents

The most noticeable cross-shore currents are rip currents. Rip currents can occur during period of high waves, as strong pulses of offshore flowing jets of water.

At Ocean beach it is not unusual for rip currents to form during periods of moderate to high surf. Rip current pulses can be associated with the arrival of large sets of waves.

4.3. WAVES

The primary cause of erosion at Ocean Beach is storm wave action. In this section, a discussion of wave origin, wave transformation, and extreme wave conditions at Ocean Beach is presented.

4.3.1. Deepwater Waves

The waves at Ocean Beach may be divided into four groups according to their

origination: Pacific anticyclones, extratropical cyclones, southern hemisphere extratropical cyclones, and locally generated seas.

4.3.1.1 Pacific Anticyclone

An anticyclone is a system of winds which rotate clockwise around a high pressure area in the northern hemisphere and counterclockwise in the southern hemisphere. It usually progresses at 20 to 30 miles per hour and has a diameter of 1500 to 2500 miles. The Pacific anticyclone is the dominant summer storm type in the eastern north Pacific. It is typified by winds out of the west-northwest to northwest. The strength of these winds, and resulting waves, are dependent on the relative position of the Pacific high pressure system and the thermal trough over Nevada and central California.

4.3.1.2 Extratropical Cyclone

A cyclone is a system of winds which rotate counterclockwise around a low pressure area in the northern hemisphere and clockwise in the southern hemisphere. It usually progresses at 20 to 30 miles per hour and often brings rain. Occurring in the middle latitudes, extratropical cyclones create the most severe waves on the California coast. They predominately occur during the winter months. Originating near Japan, these storms travel eastward to the Gulf of Alaska. Waves out to the southwest portion of these storms impact the California Coast. Some storms may originate near Hawaii. These storms create the most severe wave climate for Southern California.

4.3.1.3 Southern Hemisphere Extratropical Cyclone

Southern hemisphere extratropical cyclones, which typically travel between Australia and Chile, produce what is known as southern hemisphere swell. Southern hemisphere swell is typically long period and appears on the California coast primarily during the summer time.

4.3.1.4 Locally Generated Seas

Locally generated seas are created by the local wind climate. As can be seen from the wind rose in Plate 5, a high percentage of the local winds come from the northwest. It follows from this that a large percentage of the locally generated seas come from a northwest direction.

4.3.2. Shallow Water Wave Transformation

The deep water waves as described above are transformed by island sheltering and near shore bathymetry. These processes are described below.

4.3.2.1 Island Sheltering

Mogel, Street, and Perry, 1970, showed that Cordell Bank and the Farallon Islands focus long period wave energy onto Ocean Beach, while diverting energy from areas north and south of Ocean Beach. This conclusion was also supported by Woodward Clyde Consultants, 1978.

4.3.2.2 Refraction and Shoaling

The San Francisco ebb tidal bar has a pronounced effect on waves entering the nearshore environment. Longer period waves tend to focus from Sloat Boulevard south to Noriega Street with the highest waves at Taraval Street. This occurs most frequently with the exception being long period swell from the southwest which tends to focus energy just south of the Cliff House. There is typically a reduced effect on shorter period swell and seas at the crest of the San Francisco Bar in the vicinity of Ocean Beach. A more detailed discussion of refraction and shoaling will be presented in Chapter 5.

4.3.3. Extreme Wave Conditions at Ocean Beach

For Ocean Beach, there are no significant amounts of recorded near-shore wave-measurement data. Therefore, data from a nearby site (Farallon Islands) have been analyzed. The data from the Farallon Islands was used in the Automated Coastal Engineering System's computer program "External Significant Wave Height Analysis". The results of this program show that for the 100-year return period, a significant wave height of approximately 31 feet (Period = 17 seconds) could be expected. It should be noted, however, that for design purposes, the wave of interest will be the depth-limited wave. This is because the beach erosion control alternatives that are being evaluated are all located on the beach itself. Therefore, the deep-water waves will break and reform before they reach the structures in question. Twenty years of deep-water-wave-hindcast statistics were reported by the Corps (1987), Station 21 at 37.83N, 123.53W. These deep water wave data are presented as a wave rose in Plate 6.

5. LITTORAL PROCESSES AND SEDIMENT TRANSPORT

Littoral transport is the movement of sedimentary material in the littoral zone by waves and currents. The movement consists of alongshore transport parallel to the shoreline and onshore/offshore transport normal to the shoreline. The rate of littoral transport is dependent on the angle of wave approach, wave energy, and strength of nearshore currents.

As this is a storm damage reduction study on a sandy beach and dune system, this study focused on analyzing sediment transport processes in the study area. The original effort aimed to quantify both alongshore transport and on-offshore transport at Ocean Beach through the use of numerical models. The effort to model alongshore transport failed due to an inability to calibrate

the model. However, useful information was produced in the attempt, and that information will be presented in this chapter. In order to describe alongshore transport qualitatively, Moffatt & Nichol Engineers were contracted to investigate the sediment transport processes at Ocean Beach and to develop a sediment budget using past studies and available information. A portion of their report is included within this section. Historical data were analyzed to determine the nature and location of areas most susceptible to erosion. These areas were then modeled numerically to determine susceptibility to damage from erosion. The modeling process and results are presented below.

5.1 NUMERICAL MODELING OF ALONGSHORE TRANSPORT

Numerical modeling of alongshore transport involves the transformation of deep water waves to breaking waves and then equating the alongshore energy flux to sediment transport. This section will discuss deepwater waves, wave transformation, and sediment transport modeling.

5.1.1. Deepwater Waves

Deepwater waves exist in water depths greater than one-half the wavelength of the subject wave. At this depth, or greater, the bottom has little to no influence over the wave form. However, as the wave moves into shallower water, bottom effect will play an increasing role in wave transformation. There are little to no bottom effects on these waves. The most common deepwater wave is wind generated. The waves discussed herein are deep water waves.

5.1.1.1. Sources of Directional Deepwater Wave Information

There are few sources of directional deep water wave information in the immediate vicinity of Ocean Beach and none of these sources include southern hemisphere swell. In an alongshore transport study, all wave energy is important including the lower wave energy from the southern hemisphere. Therefore, five years of wave data, which included southern hemisphere swell, were generated for this study.

5.1.1.2. Deepwater Wave Generation

Five years of hindcast data were generated using the Wave Information Studies Wave Model, Version 2.0 (WISWAVE 2.0). The time period includes June 1982 to May 1984, June 1987 to May 1988, and June 1991 to May 1993. The first two time periods include two storm seasons of significance, the last time period is representative of the most recent time series at the time of this work. These data sets encompass time periods that survey data are available for comparison with the sediment transport modeling and that buoy data are available for comparison with the hindcast data.

WISWAVE 2.0 is a spectral wave model. Wave information was

summarized every three hours. The spectral data was analyzed and a primary and a secondary frequency event was reported for use in modeling alongshore transport. The primary frequency event was used to verify the model data against buoy data.

Three nested grids were used, one covering the greater Pacific Ocean, one covering the northern Pacific Ocean, and the last covering the west coast of the United States. Wave data was output at 4 locations for comparison with local buoys (see Table 4 and Plate 7).

TABLE 4

Buoy	Buoy Location	Hindcast Station
46013	38.2° N Lat 123.3° W Long	38.25° N Lat 125.25°W Long
46026	37.8° N Lat 122.7° W Long	37.75° N Lat 122.75° W Long
Farallon Islands	37.6° N Lat 122.9°W Long	37.50° N Lat 123.00° W Long
46042	36.8°N Lat 122.4° W Long	36.75° N Lat 122.50° W Long

Wave statistics for the hindcast time series are given in Tables A2 through A8 of Attachment A. Table A2 through A8 presents an explanation for the values given in Tables A2 through A8.

As can be seen in the tables, Root Mean Squared (rms) difference values (in meters) for the wave height vary from 0.3 to 1.1 with the average falling between 0.6 and 0.7. The hindcast wave heights are generally biased slightly lower than the recorded wave heights, but are sometimes biased high, especially in the fall and winter. These numbers can be compared with results presented in WIS Report 29 which found a rms difference value of 1.5 meters for wave heights and found the hindcast heights biased high by 1 meter for runs made with WISWAVE 1.0 for west coast buoys in the year of 1988.

The rms difference values (in seconds) for the wave period range from 1.6 to 7.1, with an average value of 4.5. The hindcast periods are consistently biased on the high side. These values can also be compared to the results of WIS Report 29 which found rms difference values of 3.5 seconds and the hindcast periods biased high by 1 second for runs made with WISWAVE 1.0 for west coast buoys in the year of 1988.

Directional buoy data were available for the 1991/1992 time period. The rms difference values ranged from 28 to 64 degrees. Hindcast directions during the summer and fall are biased to the south by up to 37 degrees. Directions in the winter and spring months show little to no bias in both directions. The effect of hindcast southern swell in the summer time was considered in the sediment transport modeling phase.

Although more buoy data exist, they were not available for comparison at the time of this report. The comparison of hindcast data to buoy data presented here is deemed adequate for hindcast verification.

As the hindcast data appears to be equal to or better in quality than previous runs made with WISWAVE 1.0, the recommendation was made to accept the hindcast data as appropriate for use in sediment transport modeling while keeping in mind the wave period bias and the wave direction bias.

5.1.2. Wave Transformation

Once waves enter water less than one-half a wave length deep, they become influenced by the local bathymetry. The bottom contours can change the direction, height, and wavelength of the waves which in turn influences the quantity of sand transported and the direction in which it is transported. Numerical models can be used along with engineering judgement, to assess the wave refraction and shoaling characteristics of the study site.

In order to prepare deepwater wave data for use in the alongshore sediment transport model, it was necessary to use two wave transformation models. The first model used was WAVETRAN. This model assumes straight contours that are parallel to the shoreline. For this study, WAVETRAN was used to transform wave data from a depth of 36 meters (the depth at which the WISWAVE 2.0 model data was reported), to a depth of 25 meters, the depth at which the second wave transformation model is used. The second model uses the actual bathymetry off of Ocean Beach and transforms the waves until breaking. Several numerical models were considered for this study, including: STWAVE, REF/DIF, and RCPWAVE.

5.1.2.1. Selection of Refraction Model

Use of STWAVE was discontinued due to South Pacific Division (SPD) concerns. The model recommended by SPD for wave transformation in place of STWAVE was REF/DIF. Therefore, only REF/DIF and RCPWAVE were tested further.

During the wave transformation studies, both RCPWAVE and REF/DIF were run on personal computers (pc's). Comparisons of results can be seen in Plates 8 through 13. The graphical output is for a line parallel to the shore, this line is labeled 7 on the depth grid. Plate 14 shows the depth grid with depths in decimeters. The depth grid includes the ebb tidal bar to the north of the Golden Gate entrance. Plate 15 presents a map which relates the

alongshore columns, shown in Plates 8 through 13, to the study area.

No gage data were available to verify the wave transformation effort. There is, however, "local knowledge" of how wave heights vary along the study area. This "local knowledge" describes wave heights along the middle reaches of Ocean Beach as being double to triple those at the ends of the beach on a West-North-West swell. RCPWAVE shows this trend (Plates 10 and 12). REF/DIF, however, does not show this trend for a 12 second wave (Plate 10), and only slightly hints at this trend for a 17 second wave (Plate 12). Local knowledge also describes higher wave heights being pushed to the north on a Southwest swell. RCPWAVE shows this trend (Plate 8), while no such trend is visible in the REF/DIF runs.

Runs for flood and ebb currents conditions were made to test the sensitivity of waves to the tidal current. A 1 m/s velocity was assumed through the Golden Gate Entrance which transformed to an alongshore velocity in the study area of 0.5 m/s. As can be seen in Plates 8, 10, and 12, the subtle differences caused by the currents are dwarfed by the variance from RCPWAVE except from column 31 to 35 where the flood current is assumed to produce an anomaly. It can also be noted that the effects of the ebb and flood currents tend to average out to the 0.0 m/s current condition.

Plates 9, 11, and 13 show the transformed wave angles at row 7 of the depth grid. RCPWAVE seems to exaggerate angle changes but the trends are reasonable. Although, REF/DIF has some odd spikes, it shows the same trends as RCPWAVE, but has a more subtle response.

As the effects of currents in the wave transformation stage appear minor and, in fact, tend to cancel out over the ebb and flood tide, any further wave study is recommended without the influence of tidal currents.

Because RCPWAVE was found to better represent the wave heights at Ocean Beach, as recounted by local knowledge, over that of REF/DIF, and because RCPWAVE is integrated into the Shoreline Modeling System (SMS), which is used in modeling alongshore sediment transport, RCPWAVE was chosen to be used in support of the alongshore sediment transport effort.

5.1.2.2. Transformed Waves Used in Alongshore Transport Model

Several changes were made to the bathymetry grid so that the transformed wave data would correspond to the alongshore transport model. The bathymetry grid was rotated five degrees counterclockwise so that the on-off shore columns would be perpendicular to the Ocean Beach shoreline. The grid spacing was reduced (cut in half) to obtain more detailed wave information, and the grid was extended southward in an attempt to alleviate any end effects. To keep the modeling as effort efficient as possible, the north end of the grid was moved southward to just north of the Golden Gate centerline.

Wave data from WAVETRAN was run through the program RCRIT, which flags calm wave events and those events traveling offshore. The data set created by RCRIT was analyzed by the program WHEREWAV, which determines representative angle bands and period bands for the input wave data. The average angles and periods of these bands were the cases run in RCPWAVE. The wave classifications for the five years of generated WISWAVE 2.0 data are presented in Tables 5 and 6.

TABLE 5

CLASSIFICATION OF COMBINED WAVE EVENTS BY ANGLE BAND

ANGLE BAND NUMBER	NUMBER OF EVENTS	AVERAGE WAVE ANGLE (W.R.T. SHORE-NORMAL)	AVERAGE WAVE HEIGHT	PERIOD BANDS
1	92	75.72	0.71	2, 3
2	1472	60.62	1.1	2, 3, 4, 5, 6, 7
3	15277	38.59	0.95	2, 3, 4, 5, 6, 7, 8
4	12337	16.54	1.28	2, 3, 4, 5, 6, 7, 8, 9
5	21311	-1.89	1.63	2, 3, 4, 5, 6, 7, 8, 9
6	5540	-27.92	0.93	2, 3, 4, 5, 6
7	2439	-43.4	0.94	2, 3, 4
8	24	-65.19	1.32	2
9	0	-	-	-

TABLE 6

CLASSIFICATION OF COMBINED WAVE EVENTS BY PERIOD BAND				
PERIOD BAND NUMBER	NUMBER OF EVENTS	AVERAGE PERIOD	AVERAGE WAVE HEIGHT	ANGLE BANDS
1	0	-	-	-
2	3324	6	0.79	1, 2, 3, 4, 5, 6, 7, 8
3	7785	7.5	1.03	1, 2, 3, 4, 5, 6, 7
4	7968	9.52	1.26	2, 3, 4, 5, 6, 7
5	13550	11.56	1.3	2, 3, 4, 5, 6
6	13756	13.45	1.36	2, 3, 4, 5, 6
7	7913	15.39	1.47	2, 3, 4, 5
8	4137	17.91	1.3	3, 4, 5
9	59	24.37	1.04	4, 5

Wave refraction diagrams for two of the period bands of 11.56 seconds and 17.91 seconds were analyzed. These diagrams were created after the alongshore model had been run and represent conditions slightly different than those used to drive the alongshore model. The period bands and angle bands used to produce the refraction diagrams were generated from five years of wave data whereas those used to run the alongshore model were produced from four years and seven months of wave data. The grid size was also modified slightly to correspond to the wave ray plotting program.

The wave ray diagrams showed converging wave rays at Golden Gate Park and northward, and showed divergent wave rays at Santiago Street and Sloat Boulevard. Except for the most southerly swell, this is contrary to "local knowledge" and is believed to be wrong. The San Francisco Bar seems to diffuse wave energy away from it, instead of concentrating the energy on the beach in front of it. This may have been due to RCPWAVE's inability to deal with caustics or it may be a problem with the plotting routine. Furthermore, refraction, diffraction, and sheltering of deepwater wave energy around Cordell Bank and the Farallon Islands was not taken into account. In any case, the refraction results are being disregarded until further analysis can be done.

5.1.3. Sediment Transport Modeling

Sediment transport modeling at Ocean Beach was attempted with the numerical model GENESIS or Generalized Model for Simulating Shoreline Change. GENESIS simulates long-term wave-induced alongshore sand transport and movement of the shoreline. GENESIS is included in the Shoreline Modeling System or SMS. The SMS is comprised of a number of data manipulation programs which aid in the preparation of input data for GENESIS.

The input data for Ocean Beach included shoreline data, wave information output from WAVETRAN, a refraction and shoaling coefficient grid obtained by running RCPWAVE simulations, the depths to which RCPWAVE transformed the waves, the location of existing seawalls, and instructions which control the shoreline change simulation.

Two sets of verification data, in the form of shorelines, were available. The wetted bounds for set 1: July 22, 1970 and September 14, 1971, and set 2: September 22, 1980 and October 14, 1985 were digitized from aerial photography (Moffatt and Nichol, 1994). The wetted bound is visible on most aerial beach photographs as a line separating the darker, saturated sand from the lighter, drier upland sand. In the 1994 study by Moffatt and Nichol, the wetted bound at Ocean Beach was most commonly found to represent the Mean Higher High Water (MHHW) datum. For the purposes of modeling shoreline change at Ocean Beach, the wetted bound was assumed to be the shoreline.

The input wave data and coinciding shoaling and refraction data were discussed above except for the set 1 verification data. Phase 2 time series wave data from the WISWAVE 1.0 numerical model were available for the 1970 to 1971 time frame. These data were transformed from deepwater to 25m depths with WAVETRAN. These offshore wave data were used with the same transformation coefficients discussed above. According to WIS report 29, the Pacific WISWAVE 1.0 wave height data are biased high, however, no corrections were attempted for the alongshore modeling.

The Start input file for GENESIS contained two calibration coefficients, K1 and K2. The K1 coefficient is proportional to sand transport produced by obliquely incident breaking waves. The recommended values for K1 are between .1 and 1.0. Due to the energetic wave climate at Ocean Beach, a value of .1 was chosen for K1. The K2 coefficient weights the value of the alongshore gradient according to breaker height. This coefficient is usually limited to 50% - 150% of K1, however, the K2 coefficients were varied using values of .1 and .4 in this study. The 400% increase of K2 over K1 was recommended by WES personnel to enable more sensitive shoreline change to alongshore currents resulting from local gradients in sea surface elevations due to wave energy concentrations or dispersion.

Results from 4 runs can be seen in Plates 16 to 18. Each Plate contains three shorelines. The 'Initial' and 'Measured' shorelines were taken from aerial photography. The 'Calculated' line is the shoreline which GENESIS produced by running the time series wave data on the 'Initial' shoreline. The non-diffracting groin shown on the right-hand side of the Plates represents the Cliff House headland and is not permeable. The seawalls shown represent the

O'Shaughnessy seawall, the Great Highway Seawall and Promenade, and the Taraval seawall.

Shorelines for the 1970-71 data set GENESIS simulation with K1=.1 and K2=.1 are shown in Plate 16. Fairly close agreement between the 'Calculated' line and the 'Measured' shoreline can be seen from cells 50 through 80 (the north central part of the beach); however, agreement for all other cells is poor. The model calculated a calibration\verification error of 23 meters. This error expresses the average absolute difference between calculated and measured shoreline positions at each grid point. In order to account for the large alongshore difference in wave heights and the resulting alongshore currents, another GENESIS run was made with K2=.4. Plate 17 shows the results. While much of the shoreline is in agreement, the south end still shows significant disagreement. A calibration\verification error of 21 meters was achieved on this run.

Shorelines for the 1980-85 data set GENESIS simulation with K1=.1 and K2=.1 are shown in Plate 18. While the north end of the shoreline shows fair agreement, the accretionary trend at the south end is not seen in the calculated line and the middle of the beach shows large differences between the calculated line and the measured shoreline. The model calculated a calibration\verification error of 49 meters. In an attempt to spread the large accumulation of sand from the middle of the beach, K2 was raised to .4. As can be seen in Plate 19, the large accumulation of sand was spread away from the middle of the beach; however, this caused some severe perturbations to occur at the north end of the shoreline. The calibration\verification error of 52 meters was higher on this run.

The 1970-71 data set appears to have better agreement than the 1980-85 data set. However it should be recognize that the 1970-71 data set represents only 1 year of simulation. Upon examination of yearly calculated shorelines from the 1980-85 data set, one can see that the shoreline progresses consistently to its final shape and that much better agreement would be reached if the shoreline evolution was stopped after one year. This illustrates an inability to vary transport patterns with the 5 years of WISWAVE 2.0 data.

Due to the inability to calibrate the GENESIS model to the alongshore transport patterns at Ocean Beach, no further work was carried out with the GENESIS model.

5.2. SEDIMENT TRANSPORT PROCESSES

Since modeling results of the alongshore transport at Ocean Beach, proved to be inconclusive, a study of historic reports and data was undertaken to describe the sediment transport processes and to develop a sediment budget for the study area. This study was completed in the form of a report (Moffatt & Nichol, 1995). A section of that report is presented below to summarize the findings.*

"Most of the information considered was developed from a review of prior studies. These efforts provide a significant body of knowledge regarding littoral processes at Ocean Beach, the

surrounding areas and in general. However, the compilation of prior works provide contradictory indications. Basically, the body of knowledge is inconclusive and is not sufficient to develop firm

* All tables, section, and figures referenced within the report summary can be found within the Moffatt & Nichol report. Plates referenced within the section can be found in this report.

estimates of transport rates and directions. This is attributed to the inherent complexity and variability of the natural system, and the high energy environment that makes data collection difficult. Impacts by man are significant. Resulting changes provide an opportunity to gain knowledge regarding littoral processes but, due to incomplete documentation, cloud the picture.

Although littoral processes at Ocean Beach are complex, some narrowing of uncertainties is possible with available information. Plate 20 provides a schematic of sand transport processes deduced from this study. Much judgment was used to develop this schematic, which should therefore be considered largely speculative. It does however provide sufficient basis for further evaluation. In general, Ocean Beach is within a cell that includes the ebb and flood bars of San Francisco Bay, the tidal exchange through the Golden Gate, the sandy waterfront on the north side of San Francisco and possibly the beaches south to Pacifica. However, the net flux of sand at the north and south boundaries of Ocean Beach is probably small relative to the on/off shore and alongshore exchange in the immediate vicinity of Ocean Beach and the San Francisco Bar. Further, net longshore transport along Ocean Beach on an average annual or longer term basis is probably small relative to along shore and on\off shore exchange. The basis for these conclusions is discussed below.

Significant man-induced changes include construction of the Upper Great Highway, related shore armoring and placement of sediment on the beaches and dunes, and possibly dredging to define and maintain the main navigation channel through the San Francisco Bar.

Construction of the Upper Great Highway between the 1890's and 1930's straightened the dune line and shifted the beach seaward several hundred feet (Plates 21 to 27). As a consequence, the Highway and supporting embankment have been subjected to episodic erosion, especially in the area south of Noriega Street. Since the 1930's, numerous attempts have been made to protect the Highway and landward improvements by shore protection structures, beach nourishment with excavated sand, and dumping of rubble and dirt. Sand losses to the large inland dune complex via wind transport have probably been reduced by construction of the embankment and the modern practice of dumping wind-blown sand back on the beach. While these actions would tend to preserve and increase the volume of sand on Ocean Beach, sand mining has also occurred, and the net supply/loss is not known, but is probably a net supply. Beach volume changes were calculated using historic shoreline changes and an assumed conversion based on the assumption that the shore normal bottom profile maintains a relatively consistent shape. An increase in total volume was calculated. However, the volume increase

was within the resolution of the method, based on consideration of shoreline variability.

The main navigation channel through the San Francisco Bar has been maintained by dredging since 1931, and possibly as early as 1922, with significant incremental deepening and widening to the present approximate dimensions of -55 feet MLLW and 2000 feet wide at the base. Since 1971, the dredged sand has been dumped on the south lobe of the San Francisco Bar, or farther shoreward, with annual quantities typically between 500,000 and 1,000,000 cubic yards, apparently decreasing somewhat over the last decade or so. Prior to 1971, the dump site was reportedly about one mile southwest of the channel, although the actual dredging practices are not defined. A review of offshore surveys show relatively minor changes to the San Francisco Bar between 1856 and 1900 (see Plate 29). Between 1900 and 1956, measurable erosion occurred along the outer perimeter of the Bar, especially in the vicinity of the dredged channel, and significant accretion occurred around the inner portion, especially near the landward side of the south lobe and near the present designated dredged material disposal area (see Plates 30-31). To the extent that the depth changes are related to dredging practices, it is possible that greater changes have occurred since 1956.

While the net volume change over the entire San Francisco Bar was small within the practical resolution of calculations, closure was not found offshore of Ocean Beach, at the landward limit of the survey overlap. The area of accretion is centered on the south lobe of the Bar, roughly in line with Taraval and Sloat Streets, and can be seen by comparing the 1900 and 1956 soundings maps (Plates 30 and 31). The zone of accretion extends through the area marked "South Channel" (which does not exist in the 1956 soundings) on the Navigation Charts. This deposition could be due to a change in tidal currents, allowing sand to settle in the area previously appearing to be a tidal flow channel. Possible causes of tidal current changes are creation of the navigation channel through the Bar, and a reduction in the tidal prism of San Francisco Bay (Sections 3.2 and 3.4). A possible source is sand dredged from the channel, although the dump site was reportedly offshore of the Bar, or sand eroded from the Bar near the dredged channel during flood tides. Another potential source is sand discharged from the Golden Gate during ebb tides. Another interpretation is that finer sands from beach and dune nourishment moved offshore under wave and tidal currents, although this is not considered likely (Technical Review Panel). It appears that a sediment budget analysis would be tentative at best without a detailed survey of this area and a comparison with the 1956 depths to identify any volume changes.

A comparison of sand grain sizes at Ocean Beach, the SF Bar, flood tide shoals within Central San Francisco Bay, and the north waterfront of San Francisco show variation, but do not preclude linkage by sediment transport. Mineralogy of sediments in these areas has been studied in detail prior to the 1970's. The sediments in these areas have similar mineralogy, and indicate the Sierras as the likely source. These data indicate that there is little or no sediment exchange between the San Francisco Bar and deeper waters. See Heavy Mineral Distribution Map on Plate 32. Some sand from the San Francisco Bar may be transported to Bolinas by currents. Since no significant accumulation is reported in this area, it is doubtful that the net loss from the Bar is

large. The mineralogy of sediments on the beaches to the south near Daly City and Pacifica are similar to Ocean Beach. Prior studies do not quantify the potential sand supply from erosion of the coastal bluffs in Daly City and Pacifica which, based on the height of the bluffs alone, appears potentially significant. However, there does not appear to be a significant sediment source or sink to the south in Pacifica that would be commensurate with significant sediment exchange with the SF Bar or Ocean Beach (Johnson, 1965).

No firm estimates of longshore sand transport potential due to wave action exist, and conclusions regarding the direction of net transport do not agree. Studies of wave refraction indicate that waves are generally focused at Ocean Beach by offshore features such as contours around the Farallon Islands and Cordell Bank, as well the San Francisco Bar (Plates 33-35). The focusing effect is so pronounced that wave caustics are predicted. Recent investigation indicates that tidal currents also appreciably refract incident waves. Wave crossings (Plates 36-37) and current-induced refraction have been confirmed through visual observations (Section 3.7). Numerical modeling to date has not been adequate to account for these conditions. Further, visual observations indicate that surf zone processes at Ocean Beach may not relate well to the CERC relationship between alongshore energy flux and alongshore sand transport potential. Finally, little data is available to verify model predictions.

A review of prior studies of wave refraction and littoral process together with common knowledge observations allows a qualitative assessment of surf zone processes and likely sand transport characteristics. Northwest wind waves, which predominate in the summer, probably induce a net seasonal southward sand transport. Long period swell from the southern hemisphere probably induces a northward net longshore sand transport occasionally from spring through fall. Neither of these conditions produce the majority of wave power incident to Ocean Beach, and therefore probably don't define the net or gross sand transport potential by wave action. Wave crossings predicted and observed to occur make it difficult to deduce the likely longshore transport directions by wave action. In fact, tidal currents and "cellular" current structures (rip currents, shoreward currents, etc.) typically dominate the surf zone. Wave refraction diagrams indicate that wave crests tend to converge toward the landward terminus of San Francisco bar, yet longshore currents diverging from this area have been observed during extreme wave power events. Alongshore sand transport probably moves northward and southward with a relatively small net rate when averaged over several years. Reversible onshore and offshore transport within the surf zone is large, owing to the large amount of wave power dissipated in the surf zone.

A detailed review of historic beach nourishment and shoreline changes show some correlation in time, and an indication of northward net longshore transport (see Section 3.4) Alongshore sand transport past the north end of Ocean Beach probably occurs. This would indicate a small northward net transport rate along Ocean Beach, related to "leakage" of sand around Point Lobos. Once sand moves near Point Lobos, wave action would likely cause a net transport toward Fort Point and eastward along the northern San Francisco waterfront (Table 3.5-1). Since there is little sediment accumulation known to occur in this area, it is speculated that

some sand is lost to the onshore via wind, but most ultimately returns to the SF Bar via tidal exchange through the Golden Gate. Further study of sediment transport in central San Francisco Bay could help define net transport rates at Ocean Beach and the SF Bar.

Net longshore transport at the south boundary of Ocean Beach is probably small. Wave refraction diagrams and observations indicate this area is a zone of lower wave height relative to adjacent sections of shore (Plate 38). There are no significant accumulations of sediment identified in this area. The bluffs to the south are eroding, and may be a source of sand to local beaches and Ocean Beach. Although outside the scope of this study, evaluation of sediment transport south of Ocean Beach is pertinent, since no physical barrier to transport exists at the southern boundary of Ocean Beach.

Significant wave focusing and breaking occurs along the north and south lobes of the SF Bar during high wave power events. It appears possible that sand is transported toward shore by these conditions (Plate 39). At the north lobe of the Bar, the sand would likely be entrained by tidal currents and carried back to the Bar or to flood tide shoals in SF Bay. At the south lobe of the Bar, waves may move sand into the surf zone. Wave action could move the sand north and/or south within the surf zone. It is proposed that some sand moves northward to balance that lost to the north past Point Lobos, circulating between the Bar, beaches, Golden Gate and possibly the flood tide shoals in the Bay.

A comparison of volume changes presented in previous sections of this report provides some insight into sediment transport at Ocean Beach. Shoreline change data were approximately converted to beach volume changes (Section 3.1). Between 1929 and 1992, an accumulation of about 3.9 million cubic yards was calculated (Table 3.1-4). Net beach/dune nourishment over the same time period is estimated to be about 1.3 million cubic yards (Section 3.4 and Table 3.4-1). This indicates an accumulation from other source(s) of about 2.6 million cubic yards over the 63 year time period. Prior estimates of potential onshore wind transport of beach sand range from 10,000 to 40,000 cubic yards per year, or about 0.6 to 2.5 million cubic yards over the 63 year period. These wind-induced losses would increase the range of required sand input to the system to between 3.2 and 5.1 million cubic yards (mcy). The change in dune face volume has been estimated to be a loss of about 1.3 mcy (Section 3.1), which would decrease the required volume input to between 1.9 and 3.8 mcy. This amounts to an average rate of 30,000 to 60,000 cubic yards per year (cy/yr) for the 63 year period. Following Plate 20, this sand supply could be attributed to onshore transport from the San Francisco Bar and/or northward net transport from the south, and would be increased by any losses past Point Lobos.

It is useful to consider the sensitivity of these volume calculations to changes in the assumed rates and quantities. Galvin (1979) and Ecker (1980) used a conversion between shoreline changes and volume changes of about one cubic yard per lineal foot of beach for one foot of shoreline movement. Their estimate was based on the assumption that most of the historic shoreline change at Ocean Beach results from erosion of sand from the upper profile, where it was placed by man, rather than a change to the entire shore face. The calculations in

Section 3.1 are based on the assumption that the entire sheriffwick moves with the shoreline, indicating a higher volume conversion of about 1.7 cy/sf. Adjusting the beach volume change quantity for a conversion of 1.0 cy/sf decreases the beach volume term to 2.3 mcy. The required sand supply to balance the budget decreases to between 0.3 to 2.2 mcy, or about 5,000 to 35,000 cy/yr. This rate is close to the assumed rate of sand losses due to onshore wind-induced transport. Since the above calculations include the change in dune volume, wind-induced losses should be defined as transport inland of the dunes, indicating that the assumed rate range of 10,000 to 40,000 cy/yr may be too high. Reducing the assumed rate of onshore transport of beach sand to 5,000 would balance the sand volume budget. However, the rates of sand transport northward past Pt. Lobos, onshore to Ocean Beach from the San Francisco Bar, and at the southern end of Ocean Beach are undefined, except that the summation of these rates should be near zero.

Shoreline position data indicate an erosional trend in the 1970's and early 1980's, and an accretional trend since. Several man-induced processes occurred in the 1970's. Sand mining had recently stopped, and the City started returning wind-blown sand to the dunes and beach in 1976. Disposal of sand dredged from the San Francisco Bar was deposited on the south portion of the Bar, or farther shoreward, since 1971. Starting in the early 1980's, a significant amount of beach and dune nourishment occurred (about 1 mcy). Therefore, sediment budget calculations were applied to the time periods of 1929-1971, 1971-1992, and 1929-1992 in an attempt to identify possible rates of sand transport at the boundaries of the study area. Table 4-1 summarizes the sediment budget calculations in terms of millions of cubic yards (mcy) for each time period. Table 4-2 summarizes the calculations, annualized for each time period, in terms of thousands of cubic yards per year. The terms and values are similar to those described above for the 1929-1992 time period. One exception is that Reach 1 is treated as a separate cell, owing to the more consistent trend of erosion (about one foot per year) found there. It is assumed that no longshore transport occurs past the southern end of Reach 1, and the net transport between Reach 1 and Ocean Beach can be northward or southward. The change in sand volume for Reach 1 is therefore treated as an input to Reaches 2-9 if Reach 1 erodes (and a loss to Reaches 2-9 if Reach 1 accretes). All other calculations are made for Reaches 2-9 only. A range of likely values is used for the quantities and rates to indicate uncertainty and provide a measure of the sensitivity of the sediment budget calculations to the values used. Additional explanation of the tables follows in the order of the items.

Volume Changes (I): are based on the sum of estimated changes in sand volume on the beach (item 1) and in the dunes (item 2) based on historic changes in shoreline and toe-of-dune-line, respectively, per Section 3.1. For beach volumes, the range between low and high is based on a range in conversion factors between 1.0 and 1.7 cubic yards per square foot of beach, as discussed above. For the dunes, it is considered even less certain that the dune face shape is constant, and the range between low and high is based on a range in conversion factors between 0 and 0.74 cy/sf of dune line change (assuming a dune height of 20 feet). Unfortunately, the dune line data used start in 1938, not 1929.

Sand Input or Losses (II): includes several items considered to be sources or sinks of sand linked to Ocean Beach. Items 3-5 are estimated based on information available in this report. Items 6 and 7 are used to balance the budget, with assumptions.

<u>Item 3:</u> Net Beach/Dune Nourishment (+) Mining (-) is the summation of estimates in Table 3.4-1, with some minor modifications. Unknown values in the Table are approximately estimated. The 1929-71 values include 160,000 cubic yards to account for the unknown quantity of nourishment in the 1942-46 time period that reportedly widened the beach 40 feet between Rivera and Ulloa Streets (Table 3.4-1). The high value used for the 1929-71 period includes an additional arbitrary increase of 200,000 cubic yards for reported nourishment associated with lot grading during residential development in the late 1940's and early 1950's.

<u>Item 4:</u> Wind Blown Loss to Inland is estimated based on the control volume including the seaward portion of the dunes, as accounted for in item I.2. The assumed rates are zero to 30,000 cy/yr from 1929-71, and zero to 10,000 cy/yr from 1971-92. The reduction is based on the City's practice of returning sand to the beach since 1975.

<u>Item 5:</u> Contribution From Reach 1 is based on the assumption that any changes in Reach 1 volume are transferred to Reaches 2-9. Bluff volume was calculated assuming an average bluff recession rate of 1 foot per year (Section 3.1 and Plate 21), existing bluff heights, and assuming that the bluffs consist of 50% to 100% sand (for the low to high range). Beach and Sheriffwick volume was calculated the same as item I.2.

Sediment Budget Balance (III): is calculated as Volume Changes minus Sand Input(Losses), and should equal zero. Items 6 and 7 were used to balance the budget, with assumptions as explained below.

<u>1929-1971:</u> Item 7 Minimum Onshore Transport From San Francisco Bar was assumed to be zero in the 1929-71 period, to account for possible impacts of dredging practices. The high value for Item 7 was arbitrarily established as 100,000 cubic yards per year for the 1929-71 period. The range for Item 6: Minimum Northward Transport Past Point Lobos was calculated, using the above assumption, to balance the budget (Item III) for the 1929-71 period.

<u>1971-1992:</u> The 1929-71 range for Item 6 was then applied to the 1971-92 period, in terms of a rate, based on the assumption that a lower rate was unlikely. Item 7 was then used to balance the budget for the 1971-92 period. This is based on the assumption that the change in dredged sand disposal after 1971 resulted in an increase in the rate of sand transport to Ocean Beach.

In effect, two "equations" were added to the sediment budget to solve for the unknowns. First, the minimum onshore transport from the Bar in the 1929-71 period was between zero and

100,000 cubic yards per year. Second, the minimum rate of sand transport past Point Lobos was the same in 1971-92 as 1929-71. These rates are considered minimums because, following Plate 20, an increase in one rate can be balanced by an increase in the other.

The results of this analysis indicate that, based on available data and assuming Plate 20 is correct, the average annual longshore transport rate at Ocean Beach is on the order of 100,000 cubic yards per year to the north. Also, there is a net influx of sediment to Ocean Beach in recent years of about 100,000 to 200,000 cy/yr, probably from the San Francisco Bar, and possibly related to existing dredging practices. The implication is that, by deepening and maintenance dredging the channel through the San Francisco Bar and dumping the sand to the south and shoreward, Ocean Beach has been nourished. This analysis is based on the assumption that the net longshore transport rate is zero at the south end of Reach 1. Therefore, an alternative interpretation of the data is that there is a net northward longshore sand transport from the shore in Daly City and Pacifica necessary to balance the sediment budget. Potential sources are the beaches and bluffs in the area. The information reviewed is insufficient to check if sufficient erosion has occurred to provide the required volume of sand, although erosion is believed to be occurring. Also, it is not clear to what extent the bluffs in Daly City and Pacifica consist of sand. Other interpretations of the data could be made, but are considered less likely or would not yield significantly different results.

These estimated sand transport rates are small relative to the amount of wave energy incident to Ocean Beach, and the amount of historic shoreline and depth changes, and beach nourishment. The calculated values are also within the accuracy of the methods used. However, it is clear that the 1992-93 shoreline positions are seaward of, or near, historic extremes, largely due to man's activities. Volume change data indicate that sand placed on the beaches and dunes has remained in the littoral system. Further, there are no indications of long-term erosion except for Reach 1, but rather a highly dynamic system with accretion in recent years (see Plates A-1 to A-10, Appendix A).

The sediment budget analysis would ideally have included considerations of volume changes to the San Francisco Bar. However, the last complete survey found was 1954-56. Also, the Bar is so large that a small systematic error in elevations would indicate an enormous volume change. Table 4-3 was developed to demonstrate this point. Volume changes calculated for the San Francisco Bar by a comparison of the 1900 and 1956 survey maps are provided in the Table, as described in Section 3.2. A net accumulation of about 18 mcy was calculated. The Table also shows the volume changes that would be calculated if there was a systematic elevation error in the data. Such a change could be related to a change in datum or sea level, or change in surveying equipment, for example. For a uniform error of 0.3 feet (1956 elevations relatively higher), the calculated net volume change (accretion) would decrease to about 3 million cubic yards (mcy). Increasing the error to 0.4 feet results in a calculated volume loss of about 2 mcy. It is interesting to note that the quantity reportedly dredged from the channel by 1956 is 15 mcy (Table 3.4-1), which is similar to the volume changes calculated for the Channel portion of the Bar (Table 4-3).

The sediment budget analysis discussed above indicated a net sand contribution to the San Francisco Bar of about 1.5 mcy (Table 4-1, Item 6 - Item 7), or 30,000 to 40,000 cy/yr (Table 4-2) for the 1929-71 time period. Following the transport processes shown in Plate 20, the contribution to the Bar is equal to the transport past Point Lobos (budget Item 6) minus onshore transport to Ocean Beach (budget Item 7), minus any losses along the way or losses due to dredged sand dumped offshore.) This contribution is very close to the net and annual volume changes found in Table 4-3, assuming a datum change or systematic error (about 50,000 cy/yr with a systematic error of 0.3 feet)

The sensitivity of the Bar volume calculations to elevation errors does not affect the significant changes found between 1900 and 1956. These include the channel, which is shown 2 to 14 feet deeper, the "South Channel" area, which is 4 to 6 feet shallower and devoid of a channel, the area closer to Ocean Beach, which is over 6 feet shallower, and the Bar crest, which generally shows a migration landward, and migration inward toward the center of the Bar or the appearance of "shrinking". Following the discussion by Galvin (1979, report 2), the South Channel could be considered a tidal flood channel often found in an ebb tidal bar near land. A possible cause of accretion in this area is a change of tidal currents related to dredging of the Bar Channel. A possible cause of the Bar "shrinking" is a reduction of the San Francisco Bay tidal prism due to filling, as identified by Gilbert (1917). The future implications of these changes could be accretion or erosion at Ocean Beach. The available data indicate that the recent impact is accretion."

5.3 ANALYSIS OF HISTORICAL PHOTOS

Historical photos from 1938 to 1992 were analyzed to develop a history of shoreline and dune line movement at Ocean Beach (Sand, 1995). A Zoom Transfer Scope was used to transfer the horizontal position of shorelines and dune lines to a base map. This base map was digitized and input to Auto-CAD for future visual and statistical analysis (Moffatt & Nichol, 1994). Shorelines were defined by the wetted bound, which is visible on most aerial beach photographs as a line separating the darker, saturated sand from the lighter, drier upland sand. In the 1994 study by Moffatt and Nichol, the wetted bound was most commonly found to represent the Mean Higher High Water (MHHW) datum at Ocean Beach. The dune line was defined by the toe of slope. Toe of slope in this study refers to the toe of dune, toe of bluff, toe of embankment, and the top seaward edge of seawall where appropriate. Where the toe was not readily visible, the most seaward location of vegetation was selected as the toe.

The analysis done by Sand, 1995, and presented in part here, used the above mentioned dune lines and shorelines to calculate rates of erosion and accretion for photographs (See Attachment B) spanning 54 years. A baseline was established along the whole of Ocean Beach. Measurements were taken from this baseline to the digitized shorelines and dune lines along transects spaced at 100 foot intervals. Measurement differences were calculated for same transects for chronologically adjacent photographs and for the 1938 and 1992 data sets. These

differences were averaged over the reaches described below and over the number of years separating the photographs in order to obtain annual rates of shoreline and dune line change.

The analysis of shoreline and dune line positions was done for nine reaches along Ocean Beach. These reaches were defined by physical features on the beach and backshore, limitations of data, and by areas anticipated to be either eroding or accreting. The reaches are shown in Plate 40 and are described as follows: Reach 1 extends from the southward limits of the data to the south end of the south parking lot. This reach is typically backed by tall erodible bluffs; Reach 2 extends northward to 225 feet South of Sloat Boulevard. This reach, and especially the southern parking lot, is critically eroding; Reach 3 extends northward to Ulloa Street and is typified by a wide dune field with a low dune erosion rate; Reach 4 extends northward to Taraval Street and was thought to have a critical dune erosion rate; Reach 5 extends northward to Santiago and is backed by the Taraval Seawall; Reach 6 extends northward to Noriega Street and is backed by the New Great Highway Seawall and Promenade except for a 300 foot gap between the New Great Highway Seawall and the Taraval Seawall; Reach 7 extends northward to Moraga Street and was thought to have a critical dune erosion rate; Reach 8 extends northward to Lincoln Way and is typified by a wide dune field with a low dune erosion rate; Reach 9 continues northward to the Cliff House and headland and is backed by the O'Shaughnessy Seawall.

Identifiable trends in the shoreline and dune line data were determined by comparing their change rates with the error in calculating the rates. There was an inherent error in the location of the digitized lines. The error in the shoreline and dune line data was taken to be 30 feet and 20 feet, respectively, per digitized line (Moffatt & Nichol, 1994). As two lines were compared at one time, their errors were added together and divided by the years between data sets to obtain an error rate comparable to the shoreline or dune line change rate calculated. If the error rate was larger than the change rate, the change rate was within the error limits and possible caused by the error. If the change rate was larger than the error rate, the change rate was considered to be real and to define a trend for that reach in that time period. Shoreline and dune line change rates are shown in Attachment B. Rates which define a trend that is considered significant are shown in bold.

Shoreline position tends to vary greatly about a mean position (Moffatt & Nichol, 1995). Analysis of the full 54 year time period shows only accretionary trends. These trends are seen in five of the nine reaches (see Attachment B). Examination of shorter time periods shows erosion and accretion, but never more time periods of erosion than accretion. Overall, it is thought that the wetted bound has maintained its mean position or has accreted. This is credited to sand placed on the beach and bar dredge material disposal practices, neither of which can be counted on for future trends (Moffatt & Nichol, 1995).

The relative stability of the mean shoreline position and the little to no loss of sand from the Ocean Beach sediment budget described above speak to the nature of the erosion problems at Ocean Beach. These erosion problems can be typified as seasonal, event driven processes. The

significance of these processes can be identified through study of changes in the dunes' positions. Study of dune position variability will define those reaches in need of protection and what that protection should be.

The dune line change rates analyzed by reach are also provided in Attachment B. Due to the high variability of the data, if one time period for a given reach showed an identifiable erosion trend, that reach was considered for additional study by the numerical model SBEACH. Reach 1 shows accretion, probably due to slumping of tall coastal bluffs (no further study recommended). Reach 2 shows a significant erosional trend from 1938 to 1948. In order to include significant infrastructure, this reach was extended to a position 80 feet north of the Sloat Boulevard centerline. The change rate was recalculated for this time period and found to be -5.1 feet per year, also a significant erosional trend. This reach was recommended for further study. Reach 3 shows accretion from 1948 to 1959 (no further study recommended, although this reach should be monitored for changes in future erosion patterns). Reach 4 shows neither erosion nor accretion (no further study recommended, although this reach should be monitored for changes in future erosion patterns). Reach 5 shows erosion from 1938 to 1948 and accretion from 1985 to 1992. The accretion could be credited to over burden from the New Great Highway Seawall and replacement of wind blown sand. There is approximately 200 feet of unprotected area between the New Great Highway Seawall and the Taraval Seawall in this reach. This area is recommended for further study. Reach 6 mainly shows erosion, however, it is already protected. Reach 7 shows erosion from 1959 to 1970 and from 1971 to 1985. This reach was recommended for further study. Reach 8 shows mild erosion. The existing dune field should provide adequate protection in this reach. No further study is recommended for immediate protection measures, however, Reach 8 should be monitored for possible critical erosion in the future. Reach 9 is protected by the O'Shaughnessy seawall.

In summary, through analysis of historical aerial photos, 3 reaches were identified as being in need of further study for determining whether immediate protection from storm damage is necessary. Further study was determined necessary if, by examination of the dune erosion rates presented above, damage to the highway, sewer transport box and/or parking lots was highly probable over the next 50 years. These reaches are defined below and are shown in Plate 41.

Reach I, 180 feet south of Noriega St. to the center line of Moraga Street (870 feet).

Reach II, From the south end of the New Great Highway Seawall Promenade to 300' south (approximately 50 feet south of the north end of the Taraval Seawall).

Reach III, From 80' North of Sloat Blvd. centerline Southward 2,680'. This area encompasses both Park Service parking lots.

To determine the severity of erosion a 2-dimensional cross-shore model is used. This model processes historic wave and tide data to predict erosion quantities. These erosion

quantities are used to make a probability distribution of annual erosion events. This distribution is randomly sampled to predict long term erosion rates. The random sampling will be used to design a Dune Nourishment Program and/or to determine when a hard structure would be needed. Discussion of erosion rate calculation is presented below.

5.4 NUMERICAL MODELING OF CROSS-SHORE EROSION

The SBEACH (Storm Induced Beach Change) computer model was used to evaluate the storm-induced response of the existing dune configuration for the 3 reaches discussed above and shown in Plate 40. Before the model was applied, it was calibrated and verified for the project site. The following paragraphs present a summary of calibration and verification of the numerical model SBEACH.

5.4.1. Data Collection

Wave information was obtained from the Wave Information Studies (WIS 1.0) Hindcast data (Phase II, Station 20) and from the 5 years of WISWAVE 2.0 data described in section 5.1.1.2. Water level information was obtained from the National Ocean Service (NOS) records of actual tide levels at the Presidio tide gage located very close to the study area. Measured profiles, extending to the water line, were available for six locations along the 3-mile stretch of beach for 4 different years. One complete set of profiles extending below the water surface was measured using a survey sled in September 1993; grain size data were also obtained. The underwater portions were then matched to the corresponding beach/dune profiles to obtain a general profile shape for each specific location. While the underwater profiles were all from a fall pre-storm survey, this was assumed acceptable since changes in the dune area are the primary focus of this study.

5.4.2. SBEACH 2.0

After setting up the configuration files, numerous calibration runs were made to obtain calibration parameters which would produce a good match between the SBEACH calculated and the measured post-storm profiles. However, a trend developed in which very little erosion occurred in the dune area, regardless of coefficient sets used. The problem seemed to be that the total water elevation was not high enough to significantly impact the dune area. Why SBEACH wasn't generating a sufficient wave setup is still not totally understood. After much data checking and more runs, the results from SBEACH were still unacceptable, and use of SBEACH 2.0 was discontinued.

5.4.3. SBEACH 3.0

SBEACH 3.0 contains an improved wave transformation function. This function simulates irregular waves and irregular wave breaking which allows smaller waves to propagate further shoreward. Using SBEACH 3.0, the calculated profiles matched much better than those

using SBEACH 2.0 as the calculated total water surface elevations were 3.5 feet higher than those calculated using SBEACH 2.0.

5.4.4. Calibration and Verification

SBEACH was calibrated by running storm data on an initial profile and comparing the resulting calculated profile with corresponding field data. Normally profiles which include data from the landward limit of erosion out to the depth of closure are used to calibrate SBEACH. In our case this data was not available. However, dune and beach profiles from the landward limit of erosion to the foreshore slope were available. Since modeling dune erosion was the primary concern, this data was considered sufficient for calibration and verification purposes.

5.4.4.1. Reaches I and II

Although there were many dune and beach profiles which coincided with available wave data, there were few data sets which showed dune erosion. Some data were available for two cross-sections (Pacheco Street and Rivera Street) between Reaches I & II. These data were used to calibrate and verify the SBEACH model for these reaches. The initial profile was taken on December 9, 1982. The final profile was taken on February 15, 1983. There was one short two-day storm before the December 9, 1982 profile was taken; therefore, these profiles are considered to be fall profiles and the tieing in of off-shore profiles from a September 1993 data set was considered appropriate.

SBEACH was designed to model erosion from single storms. Through experimentation it was determined that SBEACH worked as well on single storms as it did on multiple storms tied together at Ocean Beach. With this knowledge in mind, and the fact that the development of annual erosion rates depended on annual erosion data, not just individual storm data, it seemed appropriate that the calibration period was two months long and encompassed the major extent of erosion for that season.

Measured tides at the Golden Gate that matched the above time period were input for the water surface elevation. A total correction of 0.41 feet was added to the tide data. Part of this, 0.2 feet, was added to all elevations for geographic correction at high tide. An additional 0.21 feet was added to all elevations for storm surge or wind setup. Wind input was tested in the SBEACH model but found to have little to no effect on results. The correction for setup was derived from NC&HE, 1985, by taking the mean value of a normal distribution of the data presented. The minimum value assumed was 0 feet and the maximum value assumed was 1.5 feet.

The SBEACH model requires a value for the maximum steepness that the dune profiles may obtain. If this limit is reached during a simulation, the model triggers an

avalanche of sand, causing the dune to erode. This choice for maximum steepness varies around the angle of repose for sand. It was found that the avalanching slope needed to be calibrated for the profile that was being run. This varied from profile to profile. An avalanching slope of 50 degrees was used for Pacheco and Rivera Streets.

Another input variable is sand grain size or D_{50}. The effective dune and upper beach grain size diameter (D_{50}) used in the model simulations was 0.25 mm for all project reaches. This value was obtained by averaging several grain size samples taken in the dune/upper beach area of selected profiles. Details of the grain size sampling program are contained in the report titled "Examination of Sand Sources for Ocean Beach Dune Nourishment Project" written by Debbie Sand under contract with the S.F. District Corps of Engineers, 1994. The transport rate decay coefficient multiplier was kept constant at 0.5.

Originally wave data from the WISWAVE 2.0 model was used in the calibration runs for Reaches I and II. Erosion quantities obtained were short of those seen in real life. Farallon Island buoy data was available for this time period, and was compared to the WISWAVE 2.0 data. The WISWAVE 2.0 data showed a storm length half that of the buoy data and therefore under-predicted the erosion. From that point it was decided that the buoy data would be used in these calibration runs. Small gaps in the buoy data were filled by interpolating between the existing data.

Values for two model coefficients, the transport rate coefficient K and slope-dependent coefficient ϵ, were varied until acceptable results were obtained. Acceptable results were defined by comparing the top of dune of measured and calculated SBEACH profiles for a given simulation. The values which produced consistently "acceptable" results were determined to be $K=1.5X10^{-6}$ m^4/N and $\epsilon=0.0025$ m^2/s. The erosion calculated by the Pacheco Street run was 52 feet. This compares with a measured erosion value of 46 feet. The erosion calculated on the Rivera Street run was 33 feet. This compares with a measured erosion value of 36 feet.

The above set of coefficients was chosen to represent both project reaches (Reach I and Reach II) in the vicinity of profile lines Pacheco and Rivera since the profiles lines are located relatively close to each other and both are typical of the dune system located in these two project reaches.

5.4.4.2. Reach III

The data available for calibration/verification of SBEACH for Reach III were limited. Profiles examined were taken from Trask, 1958 for the 1956-1957 storm season. The first set included profiles taken on November 10, 1956 and February 9, 1957 for profile line L and the second set included profiles taken on April 10, 1957 and June 6, 1957 for profile lines L and M. The most landward point on the November 10, 1956 profile was at an elevation of 20.5 feet MLLW. The most landward point on the February 9, 1957 profile was at an elevation of

17.5 feet MLLW. For the purposes of comparing erosion, the February 9, 1957 line was extrapolated up to 20.5 feet MLLW.

Wave information was obtained from the Wave Information Studies (WISWAVE 1.0) hindcast data (Phase II, Station 20). These data were analyzed in WIS Report 29 which found the hindcast heights biased high by one meter for west coast buoys in the year of 1988. Based on this report, and comparisons with WISWAVE 2.0 wave statistics, WISWAVE 1.0 wave heights greater than two meters were reduced by one meter.

Tide data from the Golden Gate, with the 0.41 feet correction as described above, were used for the appropriate time period. The grain size of 0.25 mm, as described above, was used. An avalanching slope of 17 degrees was used. The transport rate decay coefficient multiplier was kept constant at 0.5.

Values for two model coefficients, the transport rate coefficient K and slope-dependent coefficient ϵ, were varied until acceptable results were obtained. The values which produced consistently "acceptable" results for the November to February data set were determined to be $K=1.0X10^{-6}$ m^4/N and $\epsilon=0.0027$ m^2/s. The erosion calculated by the model run was 28 feet. This compares with a measured erosion value of 27 feet. Attempts to calibrate the April to June data sets failed.

From Trask, 1958: "Beach eroded back between November and February and then began to build up. By April it had risen two feet over the entire width. In June it had eroded back to a position comparable with the position of the previous summer." Due to the odd patterns of accretion/erosion (accretion from February to April and erosion from April to June), the lack of southern swell component in the data, the disparity in coefficients from the November-February set vs. the April-June set, and because most of our yearly storm data is between October and April, the April-June runs were disregarded and the November-February coefficients were used to represent Reach III, south of Sloat Boulevard.

5.4.5. **Production Runs**

Below is a description of the data used to generate 24 years of dune erosion data. The dune erosion data is used to calculate a statistical data base from which erosion rates are calculated.

5.4.5.1. Wave Height Sensitivity Analysis

Before the real task of running model simulations could begin, certain criteria had to be established to govern the construction of model input data sets. One criterion was the height of the wave that would define the beginning (and end) of a "significant" storm

occurrence (i.e. a storm producing accelerated dune erosion rates relative to storms of some lesser peak wave height). This limiting wave height was necessary to reduce the available wave height data to that of only significant storms (in terms of dune erosion response) for input into the SBEACH model. The wave height sensitivity analysis was accomplished by using profile lines Pacheco and Rivera with a given water surface elevation file (the same for all simulations) and changing the constant deep water wave height from one simulation to the next to determine the wave height at which accelerated erosion occurs. SBEACH takes deep water wave heights and uses two dimensional shoaling to bring the wave heights into the breaker zone. This deep water wave height was determined to be 3 meters. Using Lotus123, 24 years of wave height and period data (19 years obtained from the Coastal Engineering Data Retrieval System (CEDRS) database for WIS station 20 and 5 years from WISWAVE II simulations) were filtered for wave height series greater than or equal to 3 meters (9.8 feet). Wave heights of the 19-year long data set were reduced by 1 meter before filtering to account for bias in the data. The resulting series were then labeled and set up as text files according to their time of occurrence in a storm year. A storm year was defined as the period from 1 October to 30 June. The text files were then imported into SBEACH as one component of a complete simulation input data set.

5.4.5.2. Water Level Input

Another required component of a storm input data set for the SBEACH model is a set of water level elevations corresponding to the dates and times of the input wave height series described previously. Actual water levels from the nearby Presidio tide gage were used for the input water elevation files. In a few instances the tide record was corrupt. In these instances predicted tide data were used. Predicted tides corresponding to the wave height series were obtained from NOS tide tables.

The following corrections were applied to both predicted and actual tide data. The geometric differences between tides at the Golden Gate and at Ocean Beach amount to +0.1 or +0.2 feet (depending on the tidal epoch) at high tide and 0 feet at low tide. As the critical tidal elevations are at high water for SBEACH, a simplifying assumption will be made that little to no effect will be noticed by raising the low tide values 0.1 or 0.2 feet and the whole tidal cycle will be raised 0.1 or 0.2 feet. Test runs were made to determine the impact of running SBEACH with wind input. The calculated wind setup was found to be negligible. Water levels were adjusted +0.21 feet for wind setup as described in section 5.4.4.1. Sea level is expected to rise at a rate of 0.6 feet per 100 years as described in section 4.1.2. Anticipated sea level rise at project year 25 (2023) was assumed. For example, for the wave and water level data from 1970, 53 years was multiplied by .6 feet per 100 years to come up with a correction of +0.32 feet for sea level rise. The effects on water levels caused by the El Niño Southern Oscillation are included in the actual tide data.

5.4.5.3. Dune Location Sensitivity Analysis

Since dune nourishment options, will, over time locate the dune face in a

variety of locations along the beach profile, a sensitivity analysis was conducted to determine the effect of varying dune location (with respect to the beach berm) on the erosion rate. For the analysis, the dune profile for Range lines 6, 8, and 11 was extended further onto the beach berm and "cut back" from there. The analysis confirmed that the dune erosion is greater when the dune is extended onto the beach berm (i.e closer to the water line), and erosion is less when the dune is located farther back on the beach berm (i.e. further away from the water line). In calculating erosion rates from the 1993 profiles, erosion distributions for varying dune locations were obtained. These dune locations included the original position or 0 feet cut, 20 feet cut, 40 feet cut, and 100 feet cut. Because of the extensive erosion on range line 6, simulations were run on a 140 feet cut profile as well. These distributions were used in a risk analysis model to obtain more realistic erosion behavior by allowing the location of the dune in the model simulation to determine the appropriate erosion distribution to use. The analysis was based on the observation that north of Sloat, the mean high water line has maintained approximately the same position since 1938. The observed recovery of the MHW line for the reaches north of Sloat cannot be assumed to be occuring south of Sloat, as insufficient data precludes any conclusions being made regarding this area and the stability of the MHW line.

5.4.5.4. Input Profiles for SBEACH Simulations

Profiles used for the SBEACH without-project (i.e. no dune nourishment) simulations were those surveyed by Sea Surveyor Inc. and Bestor Engineers during September 1993. Three of the five profiles surveyed, each extending continuously from the top of dune to about -35 to -40 feet MLLW, were used as input to the model. Range line 11 was used to represent project Reach I (about 870 feet long), range line 8 initially represented Reach II (300 feet long), and range line 6 initially represented Reach III (2,680 feet long). See Plate 41 for the location of the reaches relative to the overall study site. The profiles extended approximately 3300 feet in length, but were artificially extended and deepened near the end of the profile to prevent the model from "crashing" under certain circumstances (usually wave breaking at the seaward boundary of the input profile, which caused model instability). This procedure of arbitrarily modifying the deep end of the profiles was recommended by Randy Wise of the Waterways Experiment Station (WES) as one possible method for preventing model "crashes" without compromising the validity of the SBEACH simulation. The dune and beach part of the profile on Range line 8 was along a pedestrian path cut through the dune from the Great Highway to the beach. For this reason Range line 8 was found to be inappropriate to represent Reach II and a representative dune profile in Reach II was surveyed and tied into the off-shore portion of the Range line 8 profile.

The concept of making 24 years worth of runs assumed the runs were made on an average profile. One of the controlling factors in dune erosion is the size of the fronting beach berm. Thus and average beach berm width was calculated from the wetted bound and dune lines presented in the Moffatt and Nichol, 1994. Data from aerial photography of the following years were averaged: 1938, 1948, 1959, 1971, 1985, 1992. Data from 1970 was available but was omitted to avoid biasing from the relatively small beach berm widths in 1970

and 1971. Average beach widths were determined by integrated averages over Reach 2 for range line 6 (124 feet), Reach 5 for range line 8 (225 feet), and Reach 7 for range line 11 (220 feet). These beach widths were taken to be from MHHW, approximately +5.8 feet MLLW, to +12.5 feet for range line 11, +14.25 feet for range line 8, and +12.4 feet for range line 6. The flattest part of the beach berms of the profiles taken in 1993 were adjusted so that the beach widths would match the average widths described above.

The avalanching slope was calibrated to each profile. For range line 11 it was 25 degrees. For range line 8 it was 32 degrees. For range line 6 it was 25 degrees. Plates 46 and 47 show a plan view of the survey lines established at the study site.

5.4.5.5. Erosion Quantities

Erosion quantities calculated for the three reaches are presented in Tables 7, 8 and 9.

TABLE 7

Ocean Beach Erosion Quantities Line SF-6
(yds^3/ft of beach width)

Year	0' Cut	20' Cut	40' Cut	60' Cut	100' Cut	140' Cut
56-57	10.5	1.0	0.0			
57-58	76.0	64.0	51.0	39.0	15.0	0.0
58-59	48.0	36.0	24.0	12.0	0.0	
59-60	45.0	33.0	21.5	10.5	0.0	
60-61	48.0	36.0	24.0	12.0	0.0	
61-62	11.0	2.0	0.0			
62-63	44.0	31.0	20.0	8.5	0.0	
63-64	48.0	35.0	23.0	11.5	0.0	
64-65	32.0	20.0	8.0	10.0		
65-66	48.0	36.0	25.0	12.5	0.0	
66-67	30.0	17.5	6.5	0.0		
67-68	33.0	21.0	10.0	0.0		
68-69	69.0	56.0	43.0	31.0	7.0	0.0
69-70	96.0	82.0	70.0	56.0	30.0	6.0
70-71	50.0	46.0	24.0	12.0	0.0	

71-72	47.0	35.0	22.0	10.5	0.0	
72-73	86.0	73.0	60.0	46.0	22.0	0.0
73-74	57.0	43.0	32.0	20.0	0.0	
74-75	43.0	31.0	19.0	7.5	0.0	
82-83	80.0	67.0	54.0	42.0	17.5	0.0
83-84	25.5	14.0	3.5	0.0		
87-88	5.0	0.0	0.0			
91-92	10.0	0.5	0.0			
92-93	25.0	13.5	4.0	0.0		

TABLE 8

OCEAN BEACH EROSION QUANTITIES LINE SF8
(yds^3/ft of beach width)

Year	0' Cut	20' Cut	40' Cut	60' Cut
56-57	0			
57-58	18	8.0	0	
58-59	0			
59-60	0			
60-61	0			
61-62	0			
62-63	0			
63-64	0			
64-65	0			
65-66	0			
66-67	0			
67-68	0			
68-69	7.5	0		
69-70	27.5	17.0	6.0	0

70-71	0			
71-72	0			
72-73	25	9.0	0	
73-74	0			
74-75	0			
82-83	15	6.0	0	
83-84	0			
87-88	0			
91-92	0			
92-93	0			

TABLE 9

OCEAN BEACH EROSION QUANTITIES LINE SF11
(yds^3/ft of beach width)

Year	**0' Cut**	**20' Cut**	**40' Cut**
56-57	0		
57-58	2.5	0	
58-59	0		
59-60	0		
60-61	0		
61-62	0		
62-63	0		
63-64	0		
64-65	0		
65-66	0		
66-67	0		
67-68	0		
68-69	0		
69-70	14.0	5.0	0

70-71	0		
71-72	0		
72-73	6	0	
73-74	0		
74-75	0		
82-83	1.0	0	
83-84	0		
87-88	0		
91-92	0		
92-93	0		

5.4.6. Statistical Analysis

Long-term erosion is modeled by repeatedly sampling probability distributions of single season dune width erosion values determined from SBEACH runs. In short, 24 years of wave and water level data were used to run SBEACH and establish the probability of dune erosion. Single season dune erosion values were determined by measuring the distance between the initial top of dune position and the top of dune position after a year of storms had a chance to erode the dune. Once all the erosion data sets were calculated, each representing a different initial width for the dune, the values for dune erosion were entered into BestFit. BestFit is a computer program which calculates the best coefficients for 18 probability distributions to describe the input data set. After examining all 18 distributions it was determined that the exponential distribution was best suited to represent our dune erosion data.

5.4.7. Without Project Damages

The above probability distributions were entered into @RISK. @RISK, is a software program which randomly samples entered probability distributions. Criteria were established to sample the appropriate distribution until a certain quantity of dune had eroded while tracking the number of samples taken and the value of the last distribution sampled. The number of samples taken and the value of the last distribution are examples of output variable. Once the dune eroded the established amount the process was reiterated 5,000 times. Each time the @RISK program would track the number of samples taken, or the number of years until a certain amount of dune had been eroded. At the end of the simulation, statistics were calculated on the output variables.

The existing conditions are taken to be dune widths from April 19, 1993 aerial photography for Reach I, dune widths measured in January 1995 for Reach II, and cross-sections taken in November 19, 1991 for Reach III. These earlier dune widths can be justified for use in 1998 because of man's more recent interferences in the coastal zone which have transient impacts. Since the dune widths were measured, the new Great Highway Seawall/Promenade was completed, with the overburden added to dunes adjacent to Reach II. The parking lots South of Sloat in Reach III were reconstructed with some fill coming from wastewater facilities construction, the slopes of the dune faces fronting the lots were hardened with geotextiles and pathways to the beach were hardened with riprap. Sand deposited by aeolian transport in front of the new seawall was removed and placed in all three project reaches.

Reach I distributions were sampled until 100 feet of dune had eroded. If 100 feet of dune eroded the road would have to be closed. The mean time of occurrence was 90 years. The sewer box was not impacted during the simulations which indicates a very low probability of occurrence given the scenario.

Reach II distributions were sampled until 90 feet of dune had eroded, at which point the road would have to be closed. The mean time until this occurred was 55 years. The sewer box was not impacted during the simulations which indicates a very low probability of occurrence given the scenario.

Depending on which of four local management scenarios was chosen in Reach III, different consequences could be modeled for the without project condition. The first scenario assumed that the parking lots were repaired once half of them were damaged or erosion of 20 feet had occurred. The mean time until this occurred was 1 year. Given that this did occur, there was found to be a 36% chance annually that the road would close and a 15% chance annually that the sewer tunnel would break. Sewer tunnel breakage assumes the erosion has reached the sewer and the sewer breaks under buoyant force loads. The second scenario for Reach III, assumed that the road and parking lots were repaired once they were damaged or erosion of 65 feet had occurred. The mean time until this occurred was 3 years. Given that the parking lots and road were damaged, there was found to be a 22% chance annually that the sewer tunnel would break. The third scenario assumed that the sewer, road and parking lots were repaired once damaged, or erosion of 104 feet had occurred. The mean time until this occurred was 6 years. A 1.6% chance annually that erosion would reach the treatment plant, or 200 feet of erosion would occur, was calculated assuming scenario three. The fourth scenario assumed nothing was repaired. Under this scenario, the mean time until erosion reached the treatment plant was found to be 67 years.

From the above analysis, Reaches I and II were eliminated from further study as project damages occurred outside the 50 year study life. These reaches should be monitored for future changes in erosion patterns, however no design alternatives will be recommended at this time.

6. DESIGN OF ALTERNATIVES

This Chapter presents a summary of the coastal engineering design for three shore protection alternatives for Reach III. The alternatives investigated are dune nourishment, beach nourishment, and a Taraval type seawall.

6.1. DUNE NOURISHMENT

The dune nourishment design was analyzed with the same tools used to determine the project damages presented in section 5.4.7. The assumptions and methodology for the dune nourishment design are presented below.

6.1.1. Dune Height Sensitivity Analysis

A dune height sensitivity analysis was conducted to determine the appropriate design height for dune nourishment options. This was done by running multiple SBEACH simulations where a "test" storm with moderate wave heights and water levels was held constant while input dune profile elevations were varied. The result was that dune erosion increased significantly for heights below 25 feet Mean Lower Low Water (MLLW). Therefore, 25 feet MLLW was selected as the design height for the dune nourishment alternative.

6.1.2 Dune Location Sensitivity Analysis

Since dune nourishment options, will, over time locate the dune face in a variety of locations along the beach profile, a sensitivity analysis was conducted to determine the effect of varying dune location (with respect to the beach berm) on the erosion rate. For the analysis, the dune profile for Range line 6, was extended further onto the beach berm and "cut back" from there. The analysis confirmed that the dune erosion is greater when the dune is extended onto the beach berm (i.e closer to the water line), and erosion is less when the dune is located farther back on the beach berm (i.e. further away from the water line). From this analysis, erosion distributions for varying dune locations were obtained. These distributions will be used in a risk analysis model to obtain more realistic erosion behavior by allowing the location of the dune in the model simulation to determine the appropriate erosion distribution to use. This analysis is based on the observation that the mean high water line has maintained approximately the same position since 1938.

6.1.3. Initial Dune Widths

The existing dune width condition is taken from the cross-sections surveyed in November of 1991, for Reach III. This is the latest survey information available to the Corps. These earlier dune widths can be justified for use in 1998 because of man's more recent interferences in the coastal zone which have transient impacts. Some of these impacts include:

1) The parking lots South of Sloat, in Reach III, were reconstructed using fill material from the construction of a wastewater treatment facility, 2) the slopes of the dune faces fronting the lots were hardened with geotextiles and 3) pathways to the beach were hardened with riprap. Sand deposited by aeolian transport in front of the new seawall was removed and placed in Reach III.

6.1.4. Costs for Damages

The costs to nourish were weighed against the costs of incurring damages to the road, sewer box and parking lots. It was assumed that once the top of dune had eroded to within 10 feet of the road a cost was incurred. A standard cost was assumed, independent of exactly how much road damage was done. This cost assumed that a certain portion of the road was repaired, traffic delays occurred for four months, where appropriate the parking lots were repaired and recreation benefits credited to the parking lots were lost for four months, and there was a risk of damaging the sewer box. These costs are described in detail in the economics section and are $4,504,000 for Reach III. This cost will be coordinated with the benefits described in the economics section for the F4 package.

6.1.5. Nourishment Volumes

Nourishment volumes were based on extending the existing dune profile 100' seaward at its existing elevation and maintaining its existing dune face slope over the existing dune and beach profile and determining the volumetric difference between the two. This volumetric difference was divided by 100 (the nourishment width in feet) to get a nourishment volume/foot of nourishment. One profile was used for Reach III, Range line 6. The profile was taken September, 1993. In other words, the nourishment volume presumes that the single profile will be representative of the beach profile during any nourishment activity.

6.1.6. Nourishment Procedure

In the dune design scenario a nourished dune width and a minimum dune width are assumed for each simulation. Simulations are compared and these widths are optimized by trial and error. The minimum dune width represents the minimum acceptable distance from the top of the dune to a point 10 feet west of the edge of the road (the road is assumed too close once the top of the dune is within 10 feet of it). Once the dune is eroded to a width less than the minimum width, a nourishment is needed and the request for funds is made. After receipt of funds, which would encompass two additional seasons of erosion, the dune is nourished to the nourished dune width. Dune widths are the shortest distance from the top of dune to a point 10 feet west of the west curb line of the Great Highway. The volume of sand needed is calculated by taking the difference between the nourished dune width and the dune width after the two years of erosion subsequent to the time the minimum dune width is reached. This difference is multiplied by the volume/foot of dune width calculated for that particular reach.

Once the volume is arrived at, it is multiplied by a cost per cubic yard to produce the cost of nourishment. In the dune design presented, Reach III is nourished in the 1st year, resulting in the reach being widened 55 feet to bring its initial width to 120 feet. Reach III will be nourished two years after the minimum dune width of 110 feet is reached. It will then be nourished to the full nourished width of 140 feet.

6.1.7. Erosion Scenario

Long-term erosion is modeled by repeatedly sampling probability distributions of single season dune width erosion values determined from SBEACH runs. In short, 24 years of wave and water level data were used to run SBEACH and establish the probability of dune erosion. Single season dune erosion values were determined by measuring the distance between the initial top of dune position and the top of dune position after a year of storms had a chance to erode the dune.

6.1.8. Probability Distributions

In addition to the six probability distributions calculated to determine project damages, four more were calculated to emulate dune nourishment scenarios of 20 feet, 40 feet, 60 feet, and 100 feet.

6.1.9. Dune Nourishment Design Procedure

As the first iteration of the design macro commences, all values are initialized and a 50-year loop commences. Once inside the loop, the top of dune for Reach III is checked for its position and the proper distribution is randomly sampled for that year's erosion. A new dune position is established for that reach. That position is first checked to see if the current dune width is less than the minimum dune width. If it is, a counter is started to count years until the dune is nourished two years hence. Next the dune position is checked to see whether the dune has eroded to within 55 feet of the road. At that point half of the parking lots are assumed to be damaged, the parking lots are then repaired, costs are incurred and the dune is re-established to 65 feet west of the road. If the erosion happens to be within 10 feet of the road or closer, the whole parking lot and part of the road are assumed damaged, both are repaired, costs are incurred and the dune is re-established to 65 feet west of the road. Note that road repairs are assumed to occur during the same cycle in which they were damaged because these repairs are not dependent on the budget cycle. Another counter is set off to count the number of times that reach is damaged over the 50 year simulation. Next, a counter is checked to see whether it is time to nourish. If it is time to nourish, the nourishment width for this year is calculated by subtracting the current width from the standard nourishment width. The existing width is changed to the nourishment width and the need to nourish counter is set to zero. A cost is stored for that particular nourishment and a counter is increased which indicates how many times that reach has

been nourished in 50 years. Lastly, the quantity of sand needed thus far in the 50-year simulation is tallied for that reach.

After one iteration, a counter is checked to see whether the road had to be repaired that year. The total cost of road damage is tallied and the counters for reach damages in a year and cost of total yearly road damages are reset to zero. Next, the costs for road damage and dune nourishment are summed. The total cost of nourishment alone is tracked for the 50 years and the yearly nourishment cost counter is reset to zero. The total costs for that year are brought to their present value for summing with the other years of the 50-year simulation. The total yearly cost counter is reset to zero.

After the 50-year loop has run through, the average nourishment volume per nourishment is calculated for each reach. The total money spent on road damage and dune nourishment is calculated and the present value total cost is changed to an average annual cost. Finally, the average nourishment interval is calculated. This whole process was iterated 1,000 times twice and statistics were computed on 14 output variables. The design features generated as a result of this process are presented in the Table 10.

Based on the data that the road is damaged on average every 3 to 4 years upon implementation of a dune nourishment alternative, dune nourishment is concluded to be an unfeasible engineering solution to the erosion problems in Reach III.

TABLE 10

DUNE DESIGN DATA (construction assumed to start in 1998)		
Reach III	**Run 1**	**Run 2**
Existing dune width to edge of road in feet	75	75
Dune width till road is closed	65	65
Dune width till sewer box is impacted	104	104
Minimum dune width (once this dune width is reached, the dune will be nourished two years later)	110	110
Nourished dune width	170	170
Average number of nourishments	14.1	14.1

Volume of sand needed for 50 years (cy)	5,232,310	5,246,990
Average number of times road is damaged in 50 years	14.3	14.1
Average number of times 1/2 of parking lots south of Sloat are damaged in 50 years	15.9	16.1
Project average annual cost	$5,365,000	$5,279,000

These numbers were generated from an @Risk simulation.

6.2. SEAWALL DESIGN

The seawall concept involves the use of three protective measures to control erosion of the dune line. The measures are: the construction of a Taraval type seawall; use of excavated material for dune nourishment in the area of the seawall following construction; and the placement of riprap at the toe of the existing dune.

6.2.1 Wave Field Characteristics

The wave field was analyzed using data from both the Wind Information Studies (WIS) Phase II hindcast (Station 20) and from the Farallon Island Wave Rider Buoy. Wave heights obtained from the 20 years of WIS data were reduced by one meter in magnitude to give agreement with field data. Following this adjustment, a statistical analysis of both the buoy and the WIS data provided very similar results for the zero-moment wave height (H_{mo}) and the peak energy wave period (T_p). However, the WIS data is thought to provide a more accurate estimate of the extreme wave height, H_{max}, since the buoy data is not always reliable during extreme storm events and its period of record is relatively short. Table 11 gives the design wave heights and periods used in the design of the seawall.

TABLE 11

WAVE DATA FOR SEAWALL DESIGN	
Zero-Moment Wave Height	**Hmo = 2m (6.6ft)** annual mean value**
Zero-Moment Wave Height	**HmoW = 2.5m (8.25ft)** winter mean value*
Peak Energy Wave Period	**Tp=11s** **
Deepwater Wavelength associated with Tp	**Lo=188m (620ft)**

Max Significant Wave Height Recorded	**Hmax=8.5 m(28.1ft)***
Period associated with Max Wave	**Tmax=13s***
Maximum Period associated with 95% of waves	**T95=17s*****

*: WIS Data Only (WIS data reduced by 1m)
**: Both WIS and Farallon Data
***: Reported by Noble (1985)
Note that both the WIS hindcast data and an analysis of ten years of the Farallon Island buoy data provided very similar results for the Hmo and the Tp. The extreme wave height was estimated from the WIS data only. Both data sets are directionally averaged.

6.2.2 Design Water Elevation

The design water elevation is the elevation of the water surface that is used for project design. On the open coast, tidal stage, currents, sea level rise, wind setup/setdown and, wave setup/setdown all influence the design water level to varying degrees. In many cases, the design of a coastal structure is evaluated or based upon both the highest design water level as well as the lowest. For the seawall, only the highest design water level was used for design.

The design water level was calculated using historic tidal data, storm setup (wind and wave setup), and position-dependent estimates from Noble, 1985. The tidal statistics are calculated from 125 years of record from the Presidio Reference Station. These records include meteorological effects such as wind setup, storm surge, etc. This station is located six miles away from Ocean Beach. The difference in typical high water levels is about .2 ft higher at Ocean Beach than at the Presidio Station (NOS Tide Tables). According to Noble, the wind setup effects at Ocean Beach are larger than those at the Presidio because of Ocean Beach's exposed location. The calculations of this added exposed location effect are not discussed by Noble, but the results were used in this present study. Approximate rate of sea level rise is assumed to be .6 feet per hundred years. Calculating for project year 50 or 2048, the sea level rise is calculated to be 0.3 ft. The maximum deviation about this average sea level rise is calculated by Noble to be .5 ft by analyzing the Presidio Station record. Assuming an average of .2 ft deviation from the mean water level the maximum sea level rise could be expected to reach .5 ft by 2048. Wave setup was estimated based on recommendations from Herbich, et al.

Table 12 provides a summary of the various components in the calculation of design elevations and the values calçulated for various return periods:

TABLE 12

WATER SURFACE ELEVATION RESULT FOR SEAWALL DESIGN			
Return Period (yr)*	1	10	100
Historic Tidal Analysis (ft)** (Including correction for position)	7.2	8.1	8.8
Additional Location-Dependent Setup(ft)**	.2	.3	1.0
Approximate Sea-Level Rise (ft)**	.5	.5	.5
Wave Setup (ft)***	1.4	1.4	1.4
Total (ft,MLLW)	9.3	10.3	11.7

* - Return periods based on Noble(1985) calculations on historic tidal data only

** - Data obtained from Noble(1985)

*** - Calculated as $S=.17*H_{mow}$ based on Holman, Ch. 11,H.O.C.E.,vol 1
(How = 8.25ft for winter months (Nov-April))

A 100 year design water elevation was selected for the design of the seawall at ocean beach. The value used was rounded up from 11.7 ft MLLW to 12.0 ft MLLW.

6.2.3 Berm Elevation and Scour Depth at Seawall Toe

The design of the wall took into account the natural and seasonal variability in the beach profile. Based on historic profiles, the beach berm's lowest excursion is nearly +6 ft MLLW, while the berm's summer profile averages nearly +12 ft MLLW. Thus the maximum depth of water at the structure, without scouring, is estimated to be 6 feet (assumes a 100 yr. water elevation). It is understood that greater depths at the toe of the structure may occur, but not with enough frequency to justify influencing the design. The above estimate is also in agreement with the estimate made by Noble, 1985.

Scour at the toe of the structure is calculated using the zero moment wave height for the winter months, superimposed on the 100 year water elevations. Scour depth calculations are made primarily for the analysis of structural stability. The depth of scour can be approximated by the empirical formula given by Fowler (1992),

$$S_{max} = H_o\sqrt{(\frac{(22.72)(d_s)}{L_o} + 0.25)}$$

where:
H_o = Deep water wave height (8.25ft)
L_o = deep water wave length (620ft)
d_s = depth of water at structure (6.0ft)
S_{max} = Maximum scour depth (5.6ft)

The zero moment wave height, $_{How}$, and peak wave period, Tp for the winter period (Nov-April) were used in the above equation, to calculate an approximate maximum depth of scour.

Based on results from the above equation and results of the physical model tests conducted by Noble for the design of the Great Highway Seawall, a maximum scour depth value of 6 ft (0 ft MLLW) was chosen. This results in a maximum anticipated water depth at the toe of the structure of 12 ft following a major scouring event coinciding with a water level of +12 ft MLLW (The non-scour related erosion in front of the wall is assumed to have cut the level to 6ft MLLW prior to the scouring taking place). The slope seaward of the seawall was assumed to be constant and equal to 1:20 for this design. The Great Highway Seawall (GHS) physical model tests were conducted for similar beach conditions, wave environments, and water elevations and similar conclusions were arrived at.

6.2.4 Breaking Wave Analysis

Structures that are built on the shoreline or in relatively shallow water are subjected to design wave heights that are based on depth limited breaking. Essentially, the water becomes too shallow to allow for passage of the wave form without causing it to break. Assuming the problem is governed by linear wave theory, depth limited breaking will occur when,

$$\frac{H}{d} \geq 0.78,$$

where,
H = wave height
d = depth of water.

Table 13 presents the results of the breaking wave analysis conducted for this study.

TABLE 13

RESULT OF BREAKING WAVE ANALYSIS FOR SEAWALL DESIGN						
ds(ft)	**m (ft/ft)**	**dbmax1(ft)**	**Hbmax1(ft)**	**dbmax2(ft)**	**Hbmax2(ft)**	**T95(s)**
6	0.05	7.6	8	44	12	17

ds =depth of water at wall not including scour depth
m = slope seaward of wall, assumed constant
dbmax1 = depth where Hbmax1 breaks
Hbmax1 = height of maximum breaking wave that breaks on wall
dbmax2 = depth where Hbmax2 breaks initially
Hbmax2 = height of maximum broken wave at wall (deepwater wave height of 32 ft)
T95 = period of design wave chosen to account for 95% of waves

To further clarify the definitions of Hbmax1 and Hbmax2 the words breaking and broken are used. Hbmax1 is the height of the wave which is *breaking directly on the wall*, although it begins to break a distance equal to four times the breaking wave height, *seaward of the wall.* Hbmax2 is the height of the largest wave given the return period considered (design wave) after it has reached a depth equivalent to the depth at the toe of the structure, d_s. Therefore, Hbmax2 is the maximum height of the design wave at the wall, after it has initially broken seaward of the wall at a depth equal to dbmax2. The design period, T95, was chosen since 95% of the waves have periods smaller or equal to it and because smaller periods will generate smaller breaker heights at the wall given that other conditions remain constant.

6.2.5 Wall Height and Armor Sizing

Based on the design of the Taraval sea wall (see Plate 41) and on the requirement that the access to the beach be restricted as little as possible, the design height of the wall was chosen to be 13 ft MLLW. Plates 42-45 show cross sections of the Taraval Seawall design. This height was then used to calculate an overtopping rate under design conditions. Velocities were then calculated corresponding to the overtopping rate. It was assumed that overtopping could be modeled as a jet of water with a depth of one foot. The velocity obtained from this analysis was then used to determine the size of rip rap needed to withstand the force imparted by the water. The results of this analysis are as follows:

TABLE 14

SEAWALL DESIGN PARAMETERS			
Hb=9ft	**T=17s**	**m=.05**	**ds=6ft**
Overtopping(ft³/ft*s)	**Velocity(ft/s)**	**D50(ft)**	**W50(lb)**
9.6	9.6	1.18	180

The design weight of riprap will be increased due to uncertainties and potential inaccuracies in design methodology. Based on field experience, a W50 of one-ton is recommended. The corresponding values of the graded riprap are listed in Table 15.

TABLE 15

RIPRAP SPECIFICATIONS						
W100 max(lb)	**W100 min(lb)**	**W50 max(lb)**	**W50 min(lb)**	**W15 max(lb)**	**W15 min(lb)**	**D50(ft)**
8000	4000	3000	2000	2200	800	2.64

A D50 of 2.64ft would correspond to the necessary protection for an overtopping rate of 14.4 ft^2/s or a breaking wave height of 4.5ft impinging directly on the riprap.

6.2.6 Dune Nourishment

The seawall concept includes a dune nourishment which will cover the seawall and extend up to the present dune line (see Plates 42-44). The sand will act as a soft barrier and is the initial line of defense until the berm is eroded below 13 ft Mean Lower Low Water(MLLW), at which point the seawall will begin to influence the coastal processes. Material excavated during the construction of the seawall would be used to nourish the project.

6.2.7 Riprap Protection

The last line of defense, should significant wave overtopping of the seawall occur, will be riprap toe protection for the dunes behind the seawall. This measure should prevent sever erosion of the dune in the event of substantial wave overtopping of the wall. The riprap armoring will be placed approximately 30 ft behind the seawall and approximately 30 ft (horizontally) from the top of dune.

6.2.8 Conclusions

Of the three alternatives investigated for this shore protection study, the level of protection and effectiveness of the concrete seawall alternative is the best understood. Also, it has been pointed out in a report on coastal protection structures along the coast of California and

their effectiveness, by Fulton-Bennett and Griggs, that, "Concrete walls, in general, have proved to be the most durable type of protection structure ......". Some drawbacks that are associated with seawall structures are esthetics and narrowing of the fronting beach. The concrete seawall alternative is estimated to cost approximately 11 million dollars, or approximately $4,100.00 per lineal foot of structure. The seawall would protect Reach III (see Plate 40), extending a total of 2,680 feet.

6.3. BEACH NOURISHMENT

6.3.1 Diffusion Analysis

The beach nourishment alternative in the "Ocean Beach Storm Damage Reduction Reconnaissance Study" was designed to extend and maintain the beach at a width of 150 feet in the area south of Sloat Blvd. The equilibrium profile concept was used to estimate the quantity of sand needed. Any advance nourishment was derived using an assumed across-shore erosion rate of 2 feet/year. Diffusion of the nourishment in the alongshore direction was discussed but not evaluated. With the completed "Sediment Transport Processes Study, Ocean Beach" by Moffatt & Nichol and other recent methodologies developed by Dean and Yoo, it is now possible to do an order of magnitude analysis on the diffusion of a beach nourishment at Ocean Beach.

In this updated discussion on beach nourishment, it should be noted that the across-shore shoreline change erosion rate of 2 feet/year is more recently estimated by a shoreline change accretion rate of 1 to 2 feet/year (Moffatt & Nichol, 1995, and Sand, 1995). It should also be noted that the across-shore shoreline position is highly variable and plays no part in this evaluation of nourished sand diffusion in the alongshore direction.

The Engineer Manual "Design of Beach Fills" (EM 1110-2-3301), dated May 1995, discusses beach fill diffusion...

> longshore transport may result in end losses to a beach fill project since the fill is essentially a perturbation to the shoreline, which is out of equilibrium with the natural shoreline geometry, and the longshore forces tend to restore equilibrium by spreading the sand in the alongshore direction. In this case the local transport rate may be significantly higher than the average rate over the project as a whole, due to the different local shoreline orientation to the waves and may be a dominant process in fill loss.

Losses calculated based on diffusion concerns are somewhat independent of net alongshore transport. The beach fill essentially creates its own transport environment where the natural forces tend to mold the nourishment into the shape of the formerly linear shoreline.

These forces are based on gross transport phenomena and not necessarily on net transport phenomena. Dean, 1992, assumes that the angle of wave approach to shore normal is small and negligible which then leaves simply the breaking wave height as the driving force in Dean and Yoo's methodologies.

The reconnaissance study calls for an initial nourishment volume of 1.3 million cubic yards (cy). Approximately 130,000 cy of that volume is advanced fill designed to last an estimated ten years. Once the advanced fill has left the nourished area the nourishment is no longer effective in protecting shoreline facilities. Introducing 1.3 million cubic yards of sediment to Ocean Beach would cause this material to be subjected to gross alongshore transport mechanisms. These mechanisms would tend to rapidly distribute the nourishment material throughout the littoral cell.

6.3.2. Order of Magnitude Estimate

> Wave refraction and energy flux studies (by others) indicate a potential gross longshore sand transport rate on the order of a million cubic yards per year. However, the rate is probably less based on common knowledge observations of wave crossings and significant on-offshore sand movements within the surf zone which indicate that wave energy may be dissipated through cross-shore as much as alongshore sand movements.
>
> --Moffatt & Nichol July 1995

In addition to the above reference, bar dredging records show an annual dredged amount of 400,000 to 800,000 cy of sand. Using an order of magnitude analysis and the Moffatt & Nichol, 1995, one could suggest a gross alongshore transport rate of 500,000 cy/yr. With this large amount of sand being pushed up and down the beach, one could envision 200,000 cy/yr, almost half the gross rate, leaving a nourished site as the beaches' planform comes back into equilibrium.

Assuming 200,000 cy would be needed annually to maintain the project width, the total amount of sand needed for a 50-year project life, assuming a 1.5 million cubic yard initial placement, would come to over 11 million cubic yards. This would increase the required amount of sand for 50 years from approximately 2 million cubic yards (Reconnaissance Report) to 11 million cubic yards. The annual loss of sand would probably become less in later years as the adjacent shorelines build out, therefore making the above sand requirements somewhat conservative. This conservative estimate is considered a necessary factor of safety because of the inherent unreliability of using beach nourishment as a storm damage reduction alternative.

6.3.3. Planform Evolution Methodology

The Engineer Manual "Design of Beach Fills" (EM 1110-2-3301), dated May 1995 presents a technique developed by Dean and Yoo that...

> provides a method for estimating the percentage of beach fill material which will remain on a relatively straight coastline with no end structures for various renourishment intervals. The approach provides an equation for beach planform evolution which combines sand conservation with sediment transport processes and is expressed in terms of the fraction of sediment remaining in the placement area as a function of time.

In order to use this technique, one must know the following variables (values shown are for Ocean Beach):

B = desired berm height 15 ft MLLW
H = depth of closure -35 ft MLLW
t = time (fill life) 5 yrs
hb_b= breaker height 6.0 ft
L_f = length of the fill 5 mi

The berm height is the same as that used in the reconnaissance report. The pinch-out depth (depth of closure) used in the Moffatt & Nichol 1995 report was used here. Because of the anticipated high diffusion rate, 5 years for the time until renourishment is needed was chosen over the 10 years in the reconnaissance report. The breaker height was determined from an average significant WISWAVE 1.0 wave height after the data base had been reduced by 3.3 feet (see WIS Report 29). This average significant wave height of 5.9 feet was verified with Farallon Island buoy data which gave an average significant wave height of 6.6 feet. The WIS deep water wave was then shoaled to breaking using SPM criteria and an assumed slope of 0.02 and an average peak period of 11 seconds (obtained from the WIS data base). A refraction coefficient was obtained from figure 3.5-3 in the Moffatt & Nichol, 1995, report (see Plate 35) for the area south of Sloat Blvd. This figure shows the refraction diagram for a 10 second wave coming from a direction of 285 degrees, a typical wave from a typical direction for Ocean Beach. The shoaling/refraction coefficient approximated 1, resulting in an average breaking wave height of 6.0 feet. The minimum length of the fill was determined by fitting the criteria in EM 1110-2-3301.

Using this data, Dean and Yoo's equation predicts that, after 5 years, only 46% of the 5-mile-long fill would remain within the fill length boundaries. This means that a fill, which is approximately 7 times larger than the initial fill presented in the reconnaissance report, would have more than half its material outside the fill length boundaries in 5 years. According to the reconnaissance report, approximately 90% of the initial fill must remain in front of the protected area for the fill to be fully effective in reducing storm damage. This may still be the case in 5

years as our target area is much smaller than the 5 mile-long nourishment required for an effective nourishment. However, the sand requirements of a 5-mile-long fill include an initial fill of 10.5 million cubic yards (7 times that of the reconnaissance report fill), and maintenance fill of 200,000 cy/yr for 49 years. This totals over 20 million cubic yards.

6.3.4. Conclusion

From the cost estimates in the reconnaissance report and from the latest benefits derived for the reach south of Sloat Blvd, the beach nourishment design could approximately triple in size before the costs would exceed the benefits. According to the above analysis, in order to have an effective beach nourishment, the project would have to go up at least an order of magnitude (by a factor of 10). The benefits are not nearly large enough to support such an increase in project size.

7. REFERENCES

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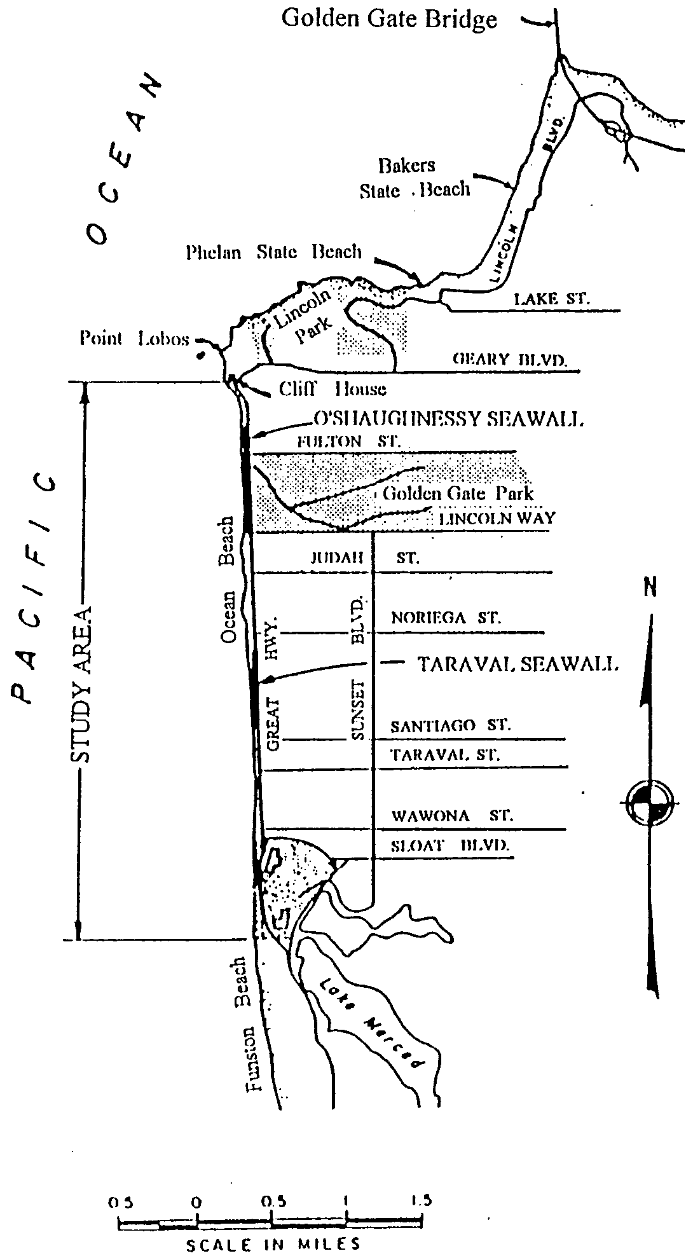
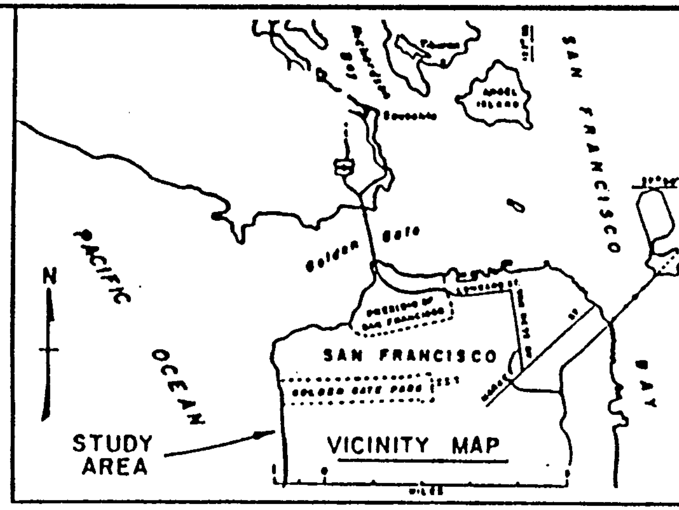
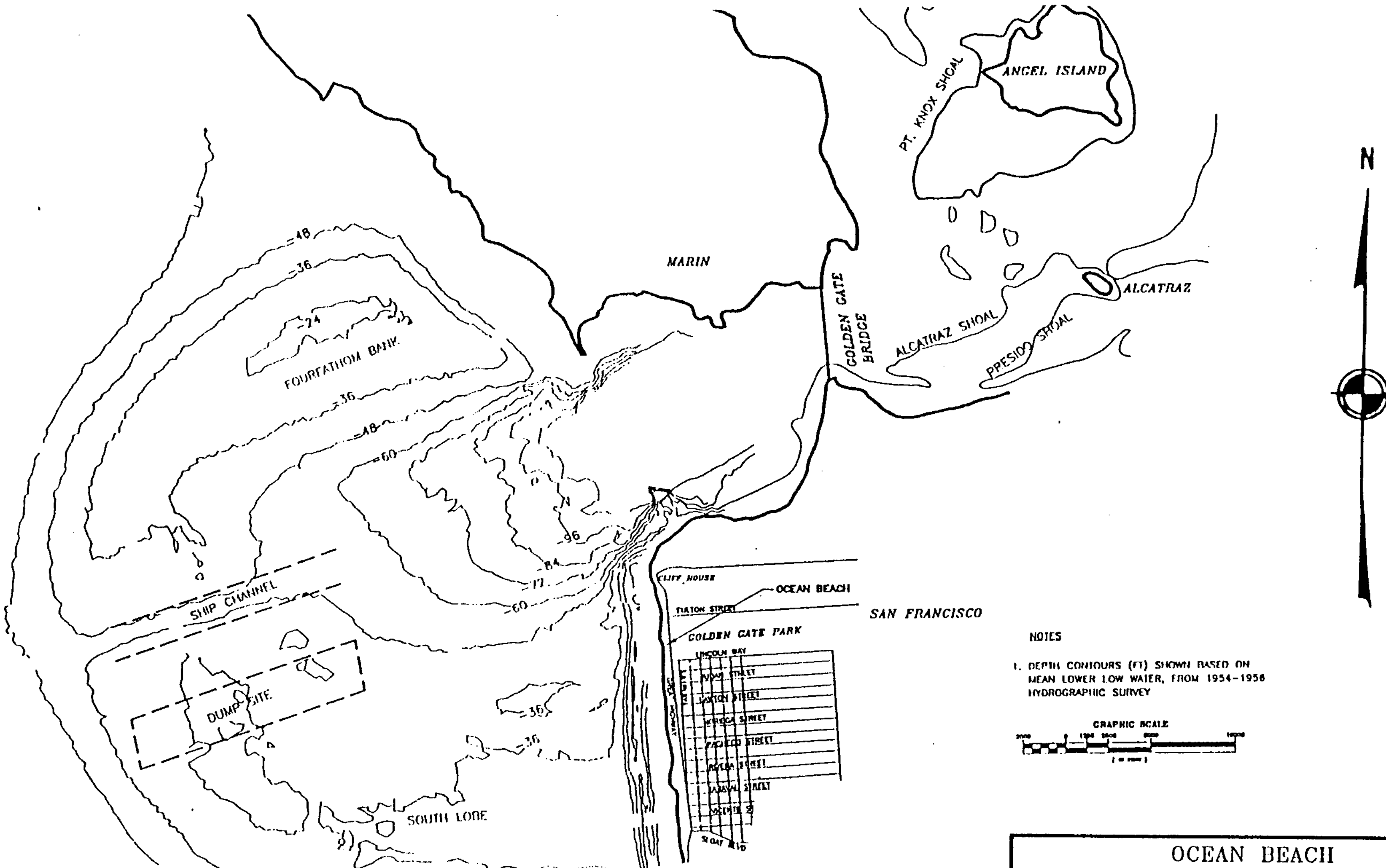




OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

LOCATION MAP

PLATE 1



NOTES

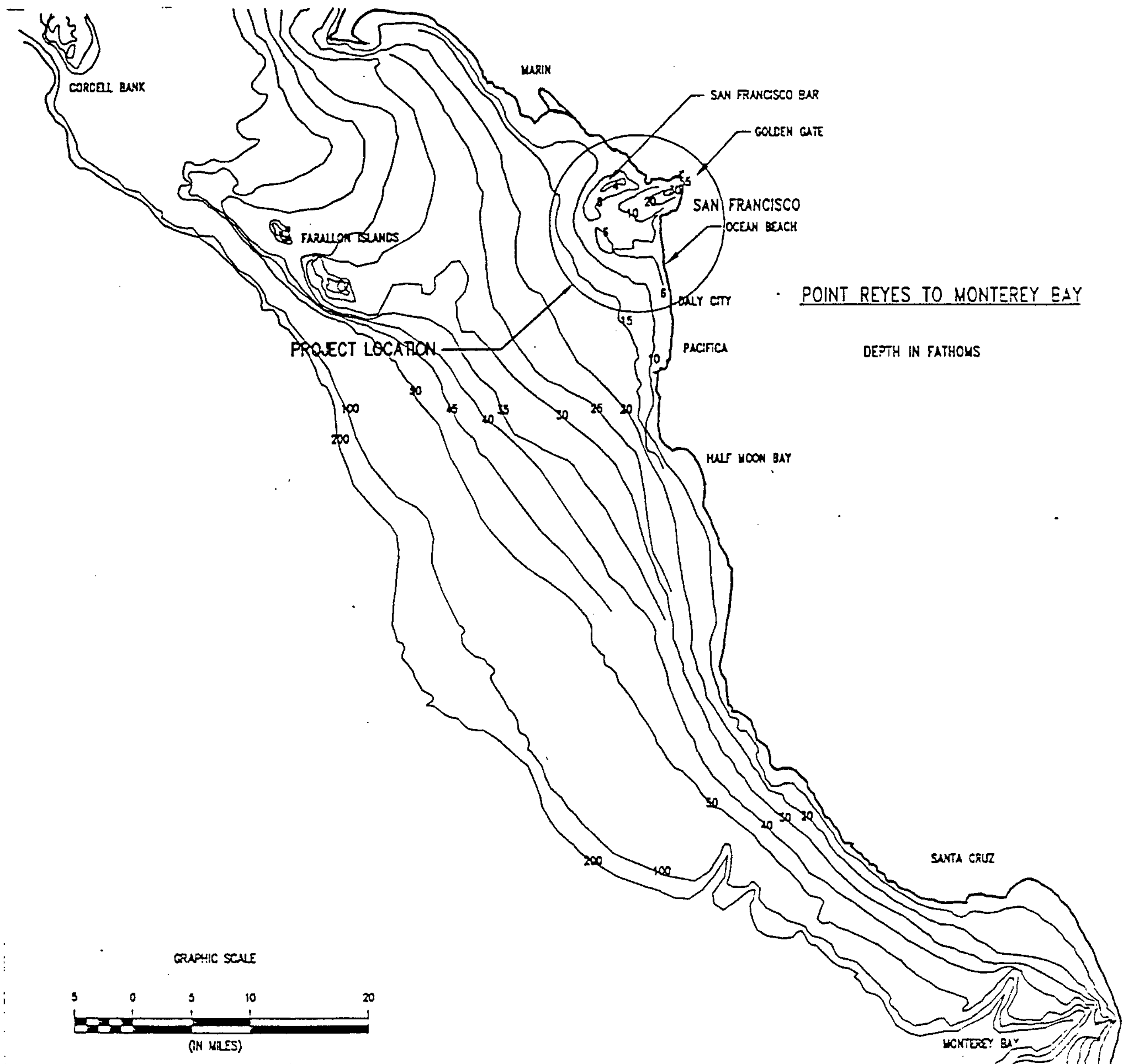
1. DEPTH CONTOURS (FT) SHOWN BASED ON MEAN LOWER LOW WATER, FROM 1954-1956 HYDROGRAPHIC SURVEY

GRAPHIC SCALE

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

NEARSHORE BATHYMETRY

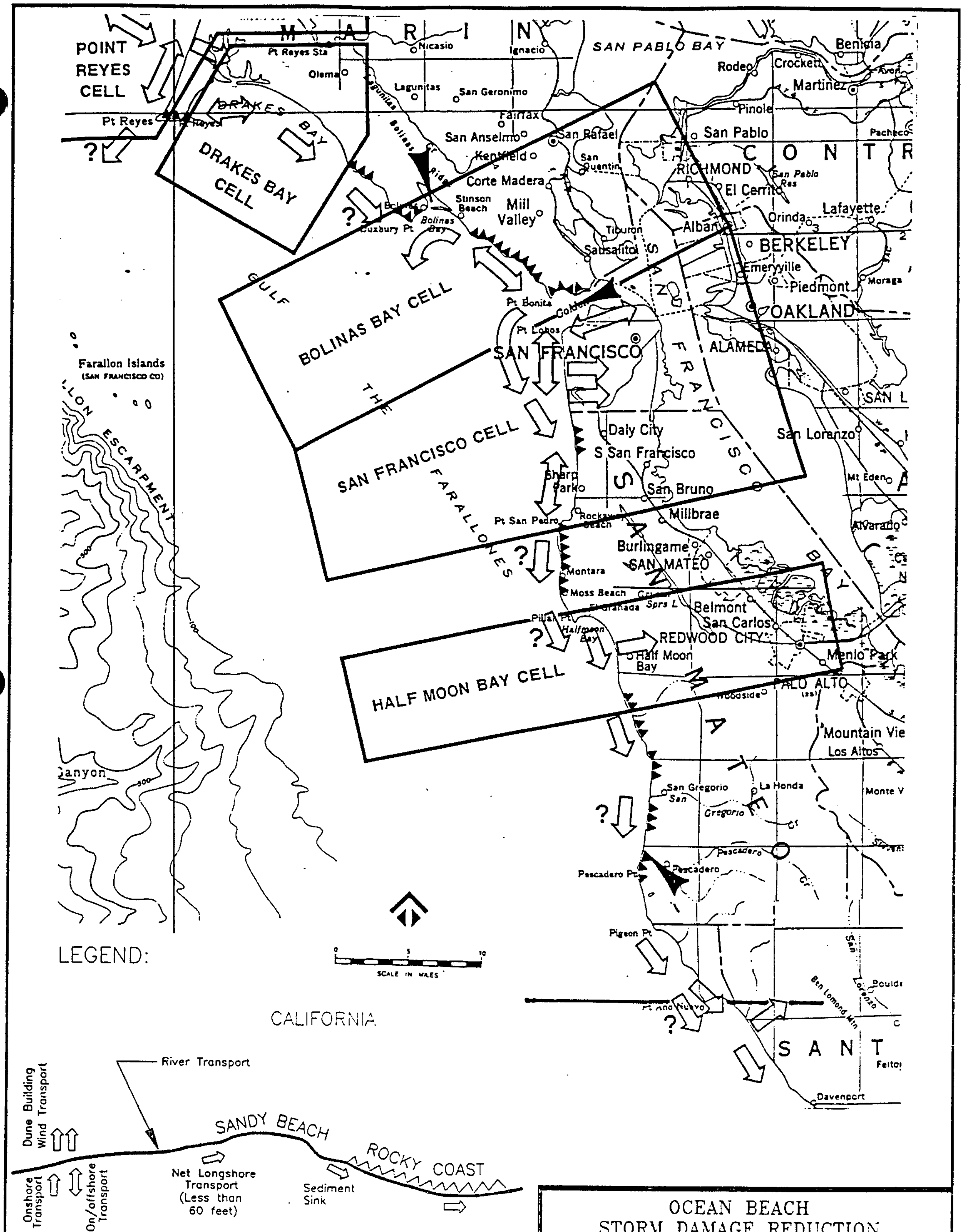
PLATE 2



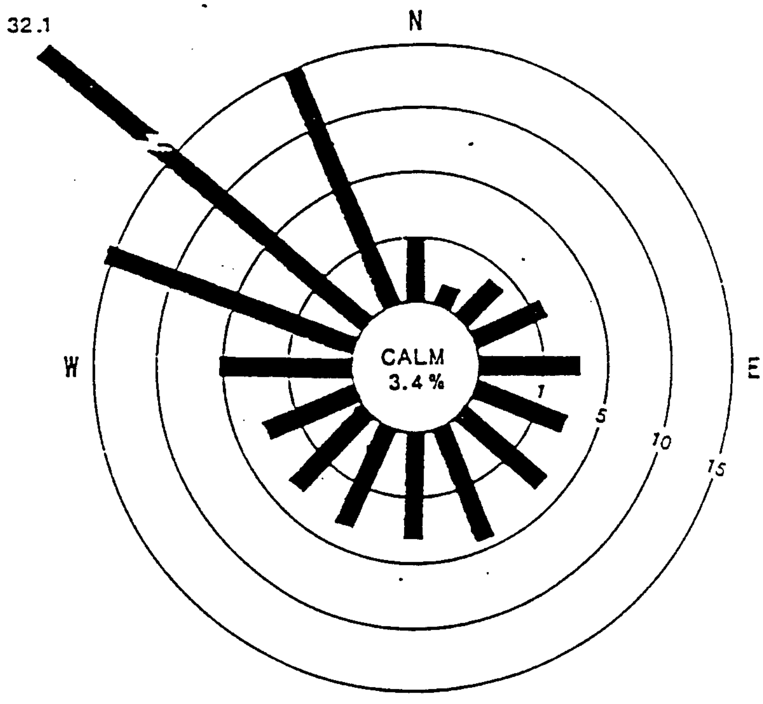
OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

OFFSHORE BATHYMETRY

PLATE 3



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
THE SAN FRANCISCO
LITTORAL CELLS
PLATE 4



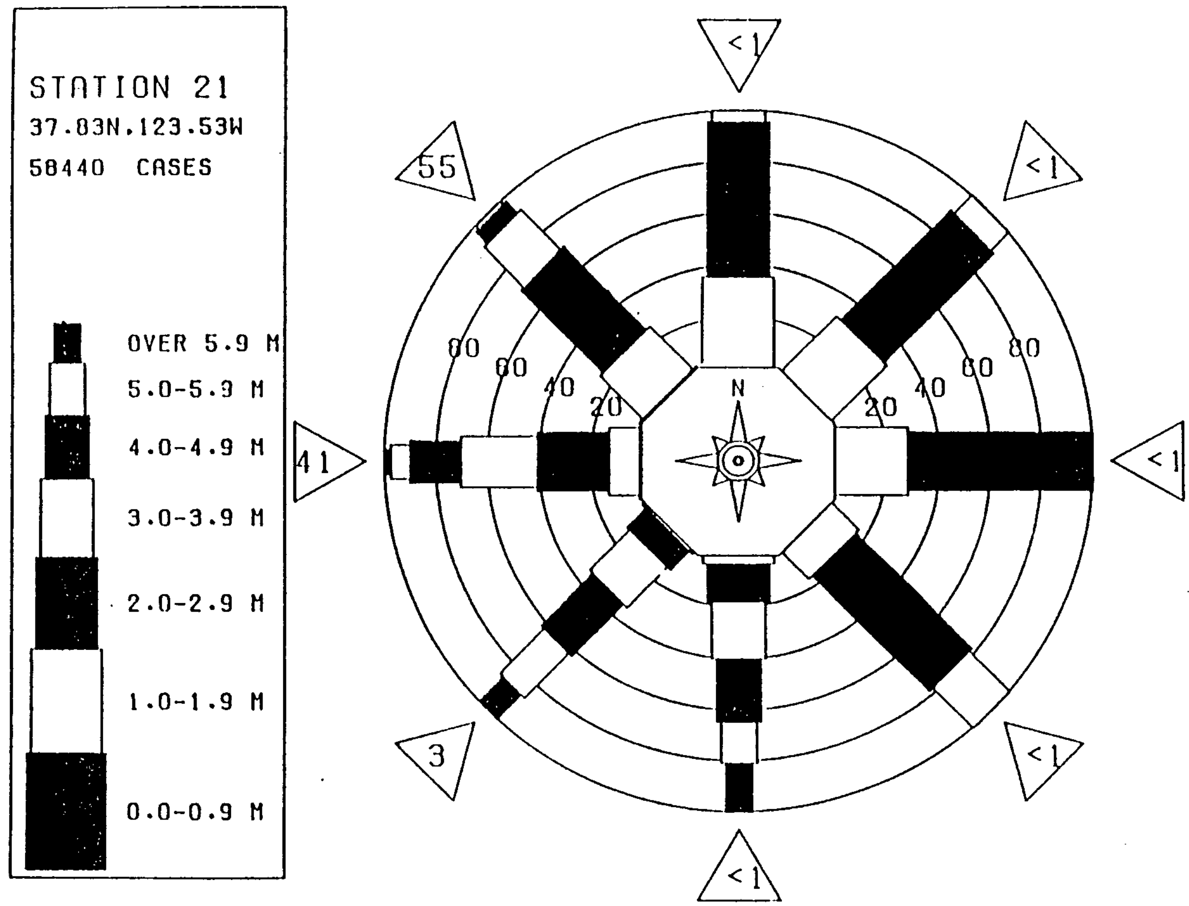
ANNUAL WIND ROSE

WIND SPEED PERCENT OCCURRENCE

DIRECTION	VELOCITY (MPH)			
	1–3	4–15	16–25	> 26
N	0.2	0.9	0.1	
NNE	0.1	0.3		
NE	0.1	0.6		
ENE	0.2	1.2	0.3	
E	0.4	1.8	0.4	
ESE	0.3	1.6	0.4	
SE	0.4	2.0	0.3	0.1
SSE	0.5	2.9	1.0	0.3
S	0.5	2.2	0.3	
SSW	0.5	2.1	0.3	
SW	0.9	2.3	0.1	
WSW	0.5	2.1	0.2	
W	0.9	3.9	0.3	
WNW	0.6	12.2	2.8	0.2
NW	1.5	22.7	7.3	0.7
NNW	0.4	9.6	4.5	0.6
CALM	3.4			
TOTAL	11.4	68.4	18.3	1.9

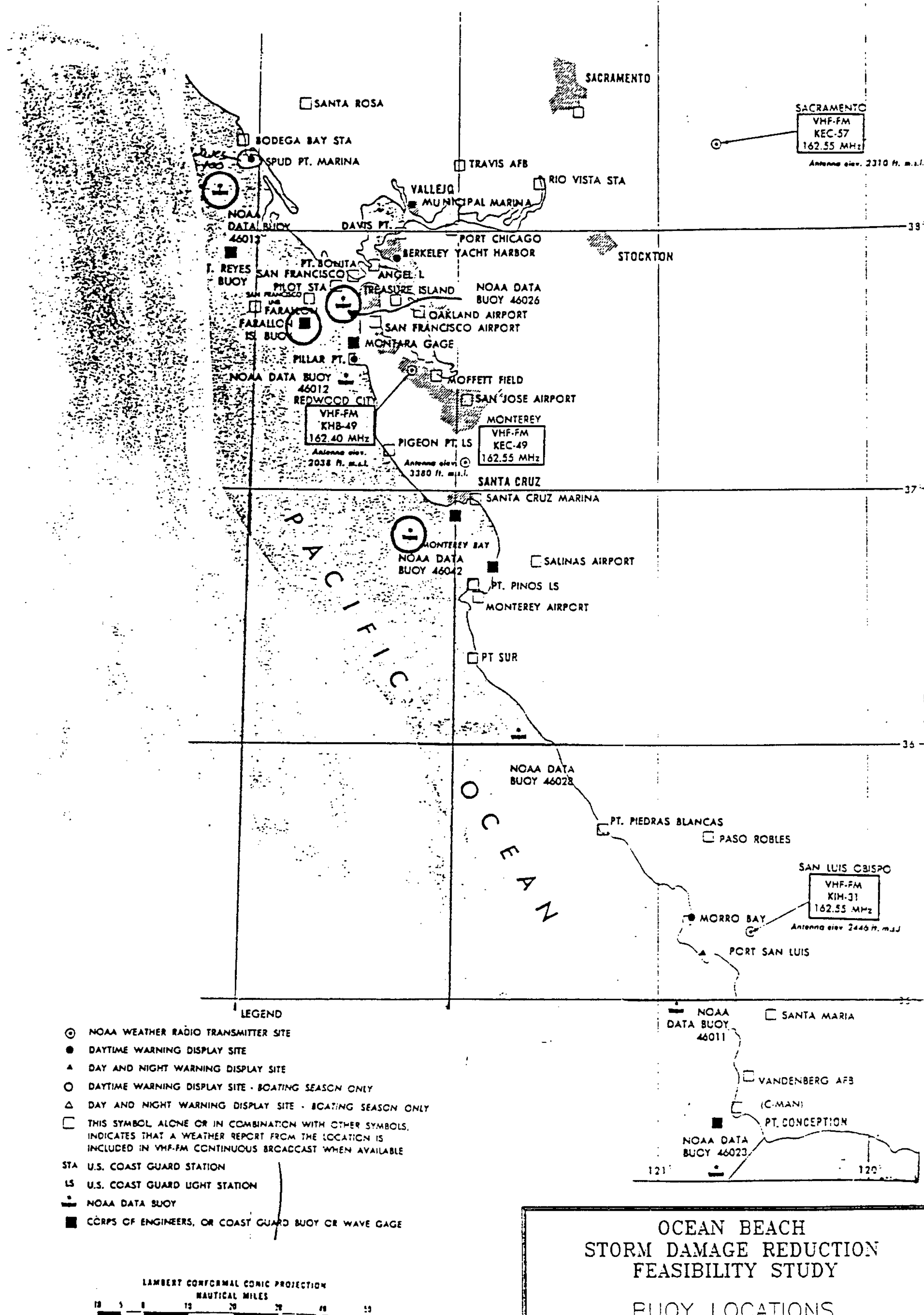
OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
ANNUAL ROSE AND WIND SPEED,
SAN FRANCISCO

PLATE 5



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
ANNUAL WAVE ROSE, 20-YEAR
HINDCAST, SAN FRANCISCO

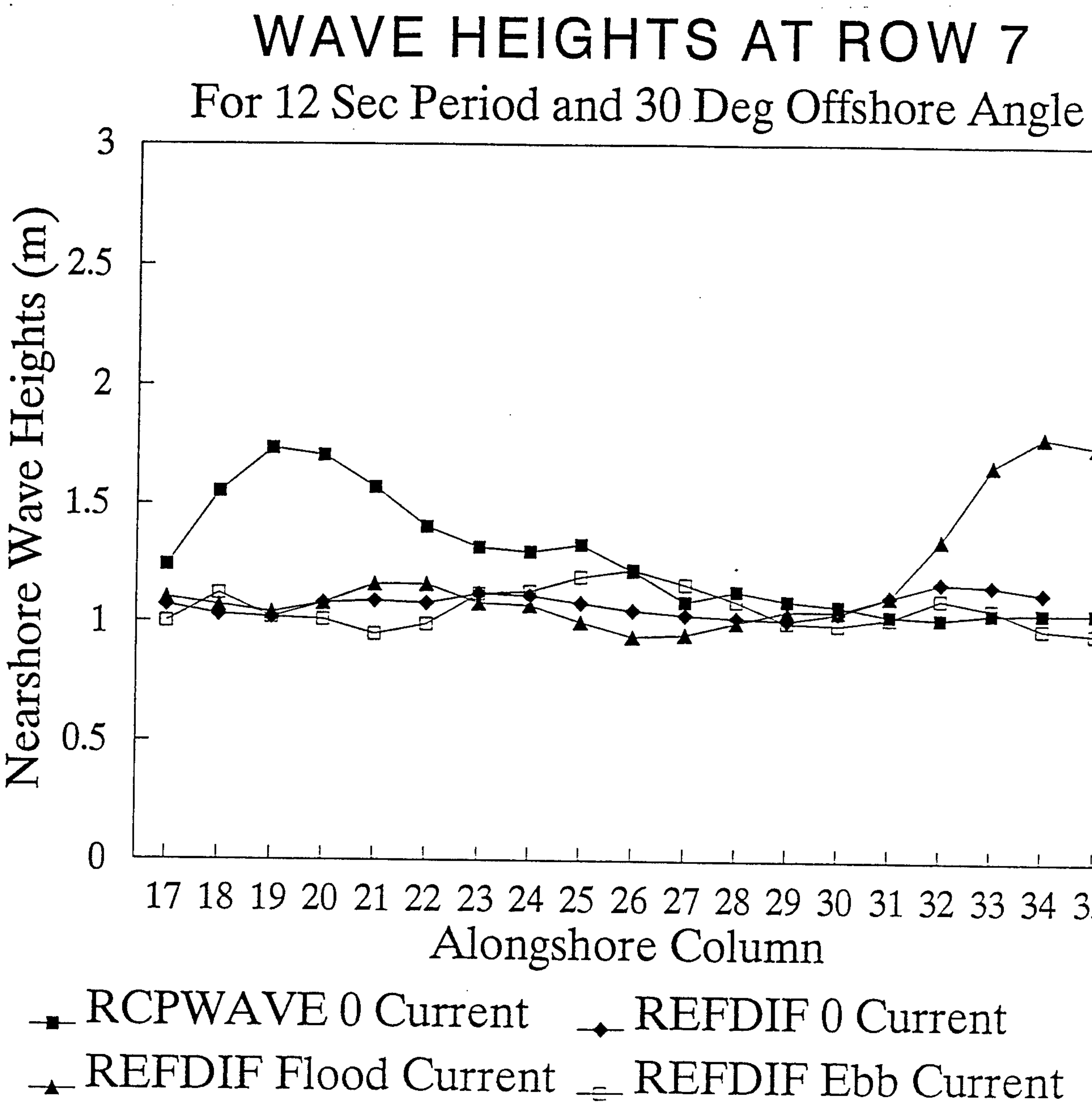
PLATE 6



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

BUOY LOCATIONS

PLATE 7

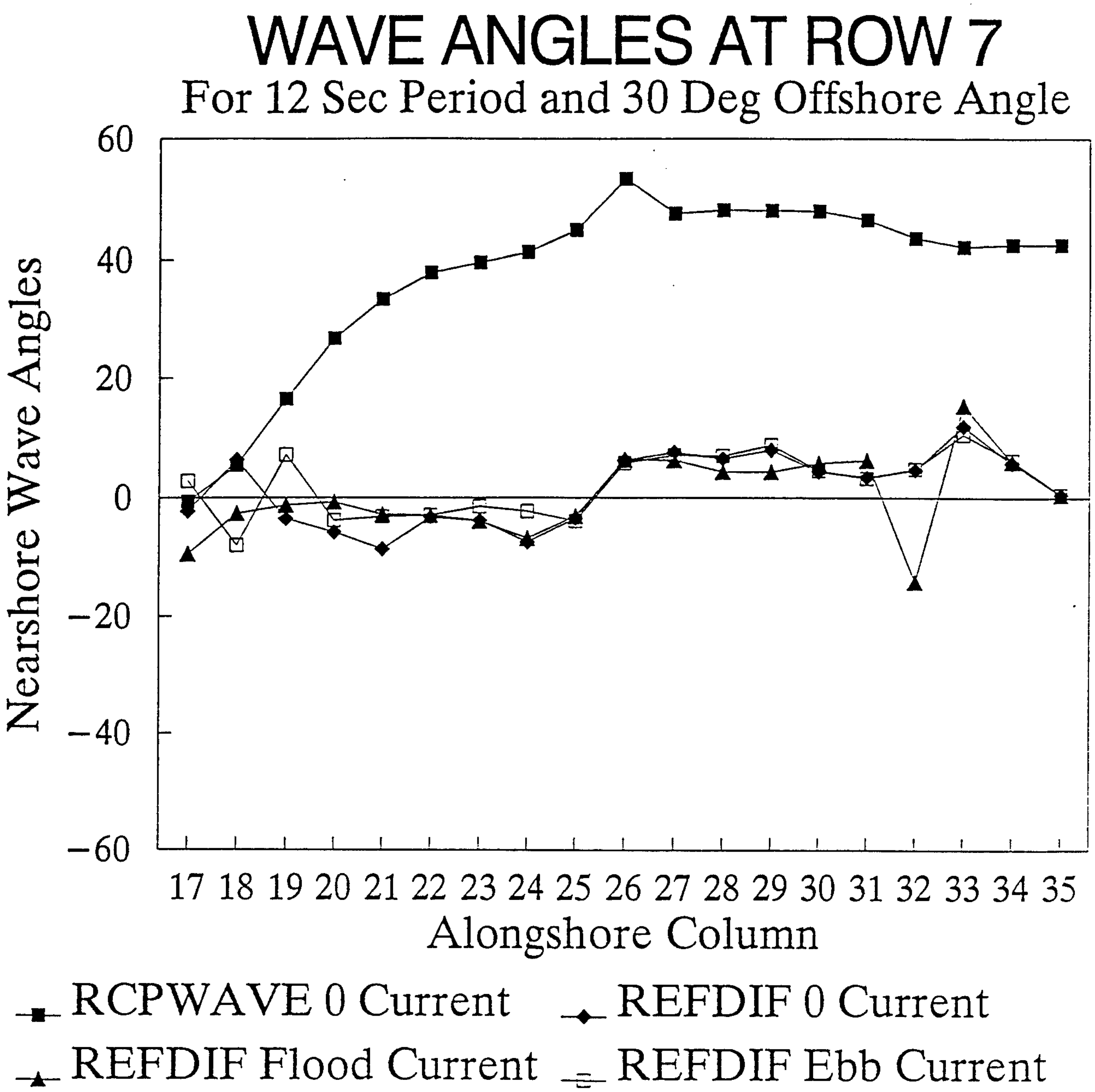


These are the RCPWAVE and REF/DIF wave heights at row 7 (see depth grid) from a unit offshore wave height for the incident angle of 30° to the east-west running shore normal (positive wave angles represent waves from south of west, negative wave angles represent waves from north of west).

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

NEARSHORE WAVE HEIGHTS

PLATE 8

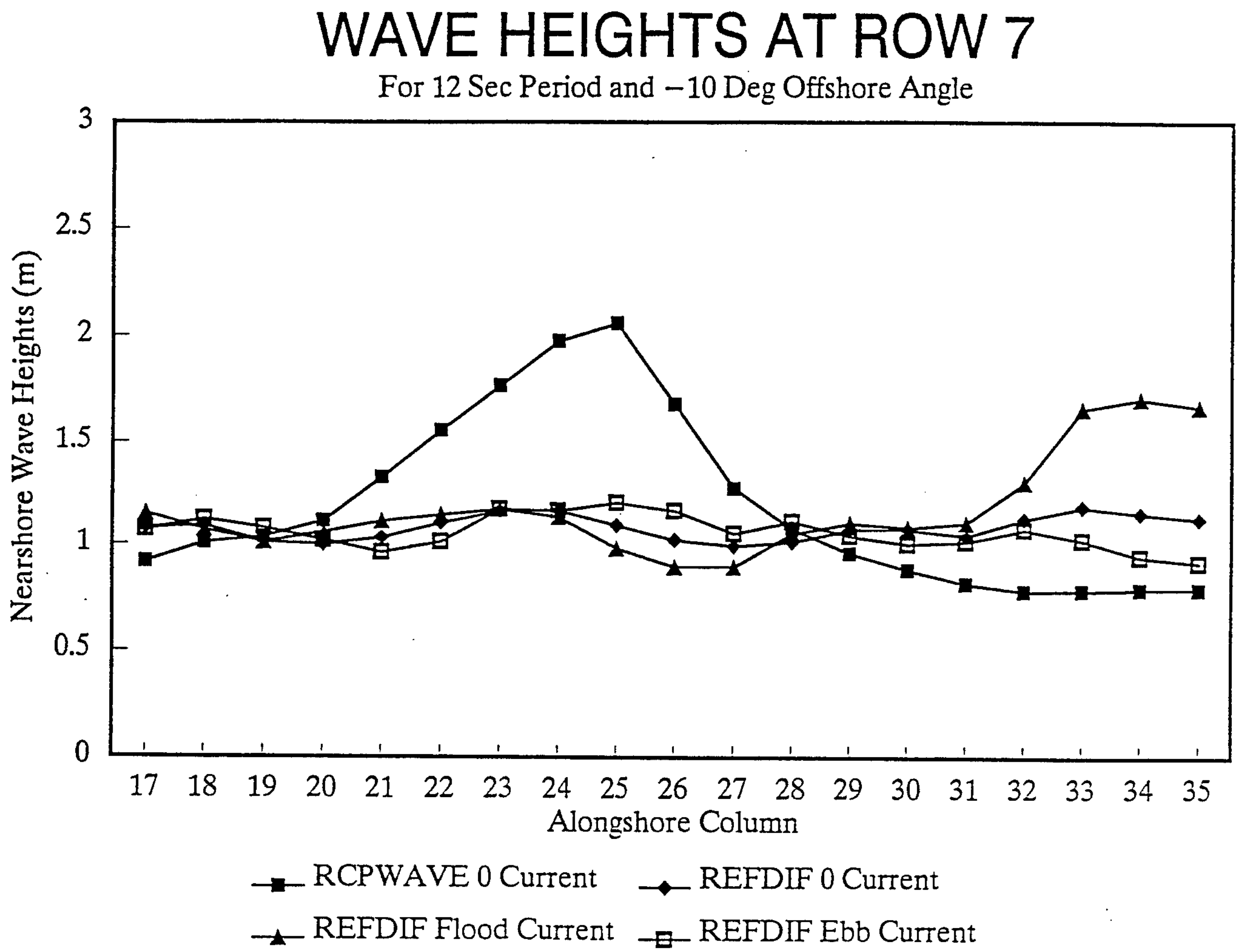


These are the RCPWAVE angles at row 7 (see depth grid) for the incident angle of 30° to the east−west running shore normal (positive wave angles represent waves from south of west, negative wave angles represent waves from north of west).

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

NEARSHORE WAVE ANGLE

PLATE 9



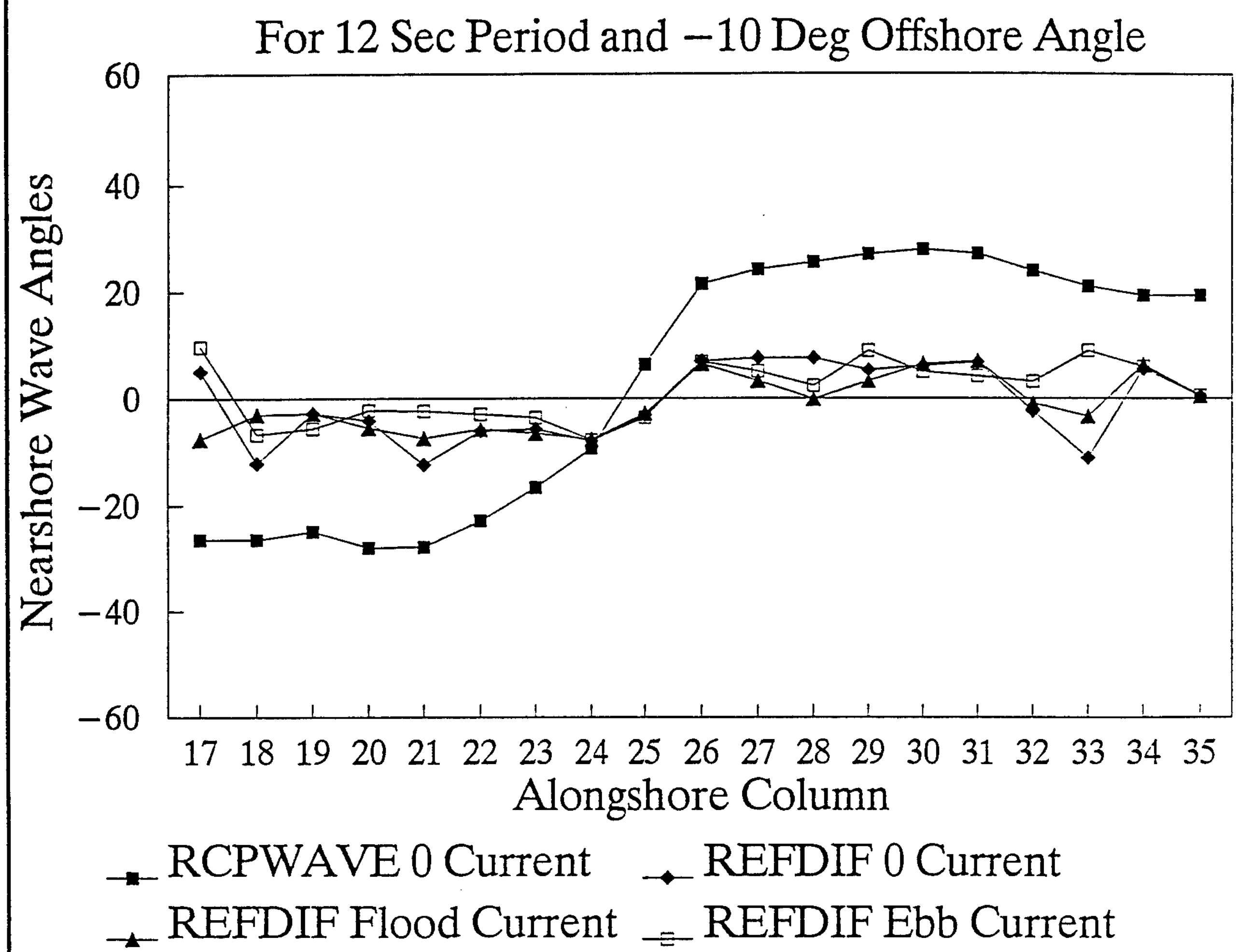
These are the RCPWAVE and REF/DIF wave heights at row 7 (see depth grid) from a unit offshore wave height for the incident angle of -10° to the east-west running shore normal (positive wave angles represent waves from south of west, negative wave angles represent waves from north of west).

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

NEARSHORE WAVE HEIGHTS

PLATE 10

WAVE ANGLES AT ROW 7

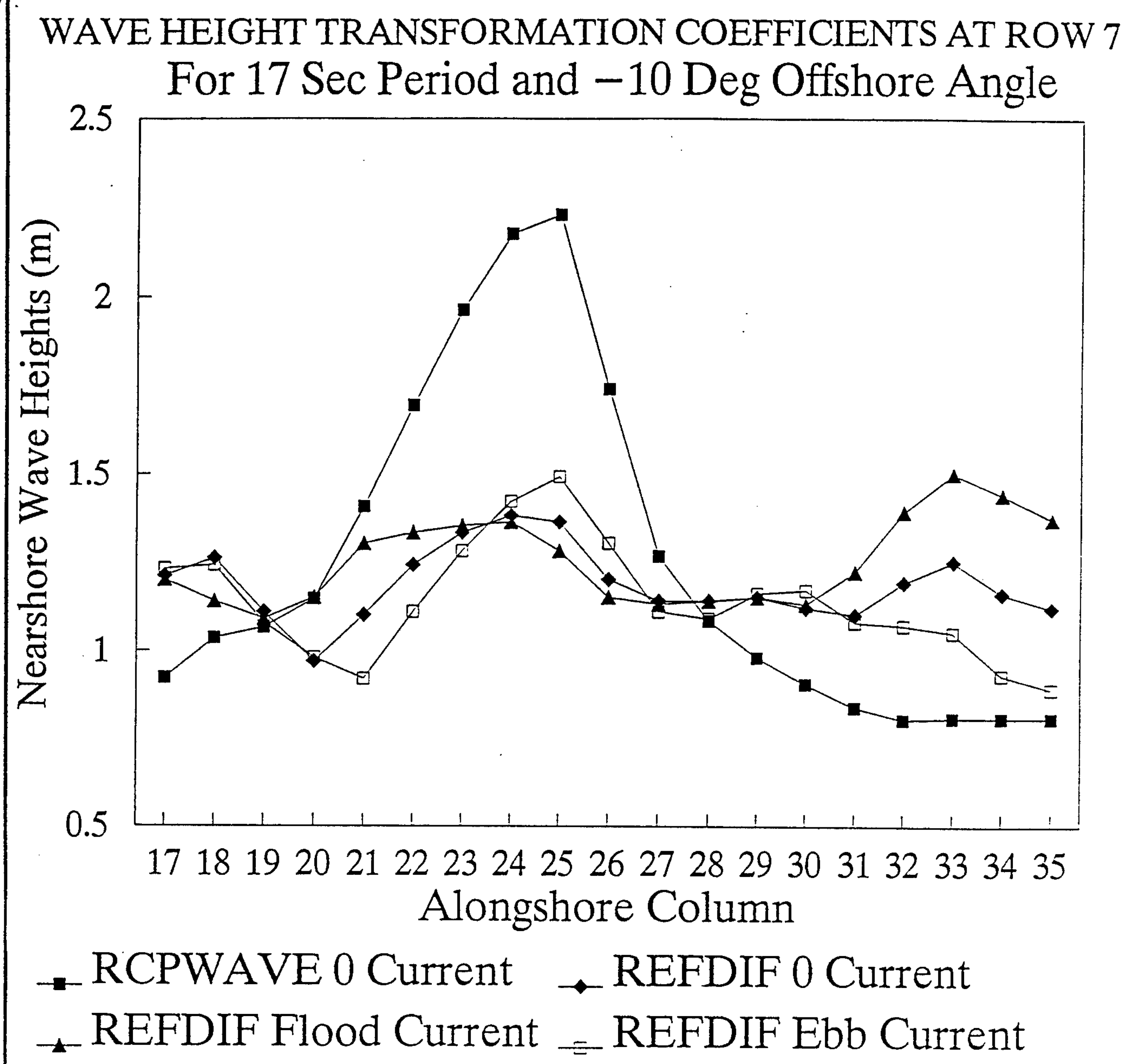


These are the RCPWAVE angles at row 7 (see depth grid) for the incident angle of −10° to the east-west running shore normal (positive wave angles represent waves from south of west, negative wave angles represent waves from north of west).

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

NEARSHORE WAVE ANGLE

PLATE 11



These are the RCPWAVE and REF/DIF wave heights at row 7 (see depth grid) from a unit offshore wave height for the incident angle of -10° to the east-west running shore normal (positive wave angles represent waves from south of west, negative wave angles represent waves from north of west).

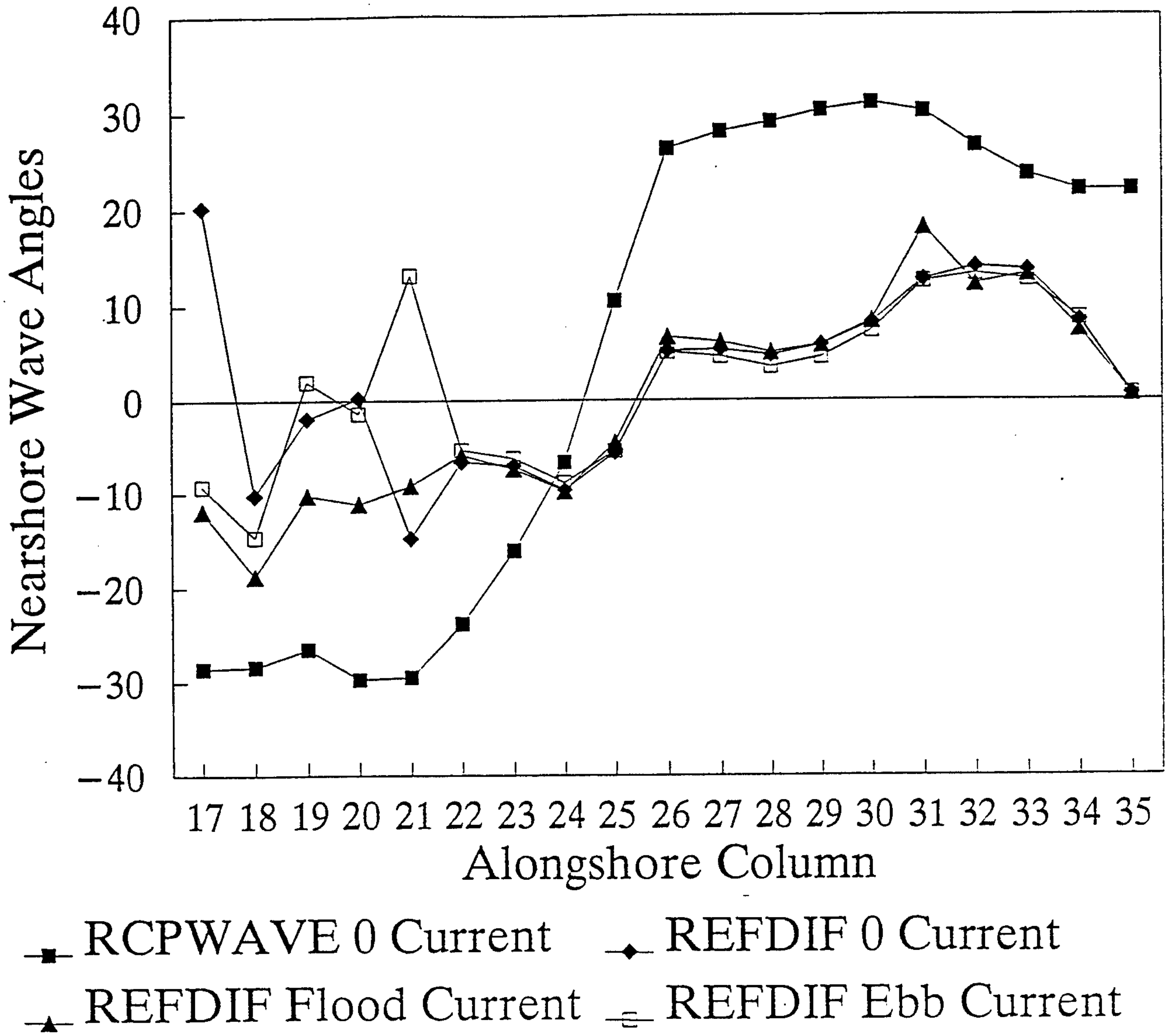
OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

NEARSHORE WAVE HEIGHTS

PLATE 12

WAVE ANGLES AT ROW 7

For 17 Sec Period and −10 Deg Offshore Angle



These are the RCPWAVE angles at row 7 (see depth grid) for the incident angle of −10° to the east−west running shore normal (positive wave angles represent waves from south of west, negative wave angles represent waves from north of west).

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

NEARSHORE WAVE ANGLE

PLATE 13

Depth Grid

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	3	3	3	3	3	3	100	400	500	500	450	450	450	200	3	3	3	3
2	3	3	3	3	3	3	100	400	500	500	450	450	450	200	3	3	3	3
3	3	3	3	3	3	3	100	300	455	450	450	450	450	200	70	3	3	3
4	3	3	3	3	3	3	100	200	400	500	400	410	450	300	170	3	3	10
5	3	3	3	3	3	3	105	170	400	500	400	400	400	340	250	40	30	50
6	3	3	3	3	3	3	105	150	350	400	400	390	400	350	285	150	60	80
7	3	3	3	3	3	3	3	140	280	500	450	380	370	350	290	210	150	120
8	3	3	3	3	3	3	3	115	200	350	450	380	350	340	310	260	185	130
9	3	3	3	3	3	3	3	3	100	250	400	380	350	320	305	260	200	143
10	3	3	3	3	3	3	3	3	100	250	400	350	330	298	290	260	210	150
11	3	3	3	3	3	3	3	3	150	250	350	325	300	285	275	260	215	172
12	3	3	3	3	3	100	100	180	125	250	350	300	290	280	270	250	220	174
13	3	3	3	3	3	125	150	220	115	220	320	290	280	270	265	248	215	176
14	3	3	3	3	3	170	200	200	110	200	300	280	280	265	252	248	212	177
15	3	3	3	3	3	200	220	115	115	175	260	275	260	260	240	238	210	179
16	3	3	3	3	120	200	200	100	110	160	235	260	245	250	220	232	205	180
17	3	3	3	3	160	190	150	90	110	160	210	250	240	235	230	220	201	179
18	3	3	100	100	180	170	125	90	110	150	200	250	235	228	220	215	200	180
19	3	3	120	180	190	130	110	90	105	150	185	245	228	220	212	205	194	177
20	3	3	170	180	175	105	90	88	105	135	175	210	225	215	205	195	185	172
21	150	150	175	180	160	95	80	90	105	130	170	200	222	210	198	188	175	168
22	150	150	170	170	150	90	80	81	100	135	150	195	218	209	192	182	170	163
23	160	160	170	155	120	80	80	84	100	130	150	200	210	200	187	176	168	161
24	160	160	170	140	111	82	80	82	100	110	150	175	200	190	182	171	165	157
25	160	160	170	140	110	84	80	81	98	108	150	165	190	188	177	171	163	155
26	165	165	170	140	110	85	80	80	90	100	140	157	180	182	172	170	159	150
27	168	168	165	145	110	90	80	80	89	100	120	150	170	175	169	163	154	148
28	170	170	165	150	115	90	80	80	89	99	120	140	165	170	167	160	155	147
29	180	180	170	150	125	100	80	80	82	98	110	137	160	168	163	159	156	144
30	175	175	170	150	127	110	80	80	80	90	108	130	153	161	161	157	160	142
31	180	180	170	160	135	115	85	80	80	90	105	120	150	145	158	160	159	141
32	175	175	170	165	140	125	92	80	80	90	100	119	140	150	153	152	153	143
33	180	180	180	156	150	125	97	83	80	84	97	112	135	155	149	143	150	143
34	188	188	180	175	158	130	100	89	80	80	90	110	132	140	142	135	140	147
35	192	192	186	178	165	140	114	92	81	80	90	107	130	140	135	125	135	150
36	194	194	188	180	166	155	120	100	88	84	90	105	125	135	125	118	120	150
37	197	197	190	185	170	160	130	105	90	88	89	100	115	130	110	113	119	150
38	200	200	199	194	175	165	140	112	99	90	88	93	110	118	110	115	119	150
39	210	210	210	198	180	172	150	120	103	94	90	88	100	108	110	115	120	140
40	209	209	213	210	188	180	165	135	110	100	90	90	97	100	111	115	120	133
41	213	213	218	213	197	186	170	155	125	105	98	94	95	100	107	114	117	130
42	220	220	220	218	205	195	180	160	140	115	105	98	97	99	105	111	117	127
43	220	220	222	224	210	204	190	175	160	130	112	105	100	100	104	110	116	125
44	225	225	225	230	215	210	200	190	172	150	125	110	105	105	105	110	118	127
45	231	231	230	233	219	228	220	205	181	165	140	125	115	110	110	113	118	130
46	235	235	240	239	230	230	228	210	190	178	160	140	128	120	125	121	130	137
47	240	240	241	244	241	239	235	216	208	190	175	155	150	140	135	130	140	135
48	237	237	242	247	246	245	230	230	228	200	190	175	167	155	150	150	150	145
49	244	244	245	247	260	248	245	245	232	220	200	190	180	173	170	165	170	170
50	242	242	245	250	260	260	260	250	244	240	225	210	195	190	185	182	180	180
51	243	243	245	250	260	260	260	260	255	245	258	237	215	203	200	197	190	185
52	242	242	245	245	250	260	250	250	251	248	250	250	235	215	213	210	206	190
53	255	255	260	260	260	260	260	257	262	260	260	260	250	235	222	219	212	203

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	3	3	3	3	3	3	3	3	3	3	10	35	70	70	90	110	110
2	3	3	3	3	3	3	3	3	3	3	10	35	70	70	90	110	110
3	3	3	3	3	10	15	20	27	35	50	60	80	90	110	115	130	130
4	30	20	30	30	40	50	40	45	65	75	100	110	115	120	135	140	140
5	70	60	60	70	70	70	60	70	100	110	114	118	134	131	140	150	150
6	113	105	105	100	105	90	75	90	110	112	115	122	128	140	145	160	160
7	118	130	120	115	111	104	80	101	110	113	117	122	132	142	150	170	170
8	130	132	120	117	111	105	83	102	110	113	117	120	133	147	158	176	176
9	140	125	115	115	110	102	88	102	110	113	117	120	131	153	166	184	184
10	142	122	110	110	112	100	92	102	110	113	117	120	133	152	172	188	188
11	140	122	110	110	110	100	95	103	110	113	117	122	132	154	175	193	193
12	142	123	110	110	110	102	97	105	110	113	117	123	135	156	176	194	194
13	154	128	110	110	110	103	100	107	110	112	117	123	138	157	177	196	196
14	154	128	110	110	110	105	102	110	110	113	117	123	140	157	180	199	199
15	156	130	110	110	110	107	103	104	110	113	117	123	141	158	185	205	205
16	160	135	113	110	110	109	104	104	110	113	117	123	140	158	190	215	215
17	160	140	118	113	113	110	106	105	110	114	119	127	143	163	190	220	220
18	161	141	117	115	115	112	108	105	110	113	119	128	144	165	194	224	224
19	162	140	117	118	118	114	109	105	110	113	119	128	146	168	200	228	228
20	162	134	118	120	120	115	110	106	110	113	119	130	147	168	202	232	232
21	158	131	119	124	122	115	110	106	110	114	120	131	150	178	210	240	240
22	158	130	120	130	122	115	110	107	110	115	120	133	155	182	217	240	240
23	154	130	130	132	120	116	111	107	110	115	123	135	156	185	224	250	250
24	152	130	135	132	121	117	111	108	110	115	125	140	160	190	228	252	252
25	149	134	140	130	122	117	112	108	110	115	126	145	165	192	230	253	253
26	148	139	140	130	121	116	112	109	110	119	130	148	170	210	230	253	253
27	146	140	140	128	120	115	111	109	113	119	132	152	180	207	240	255	255
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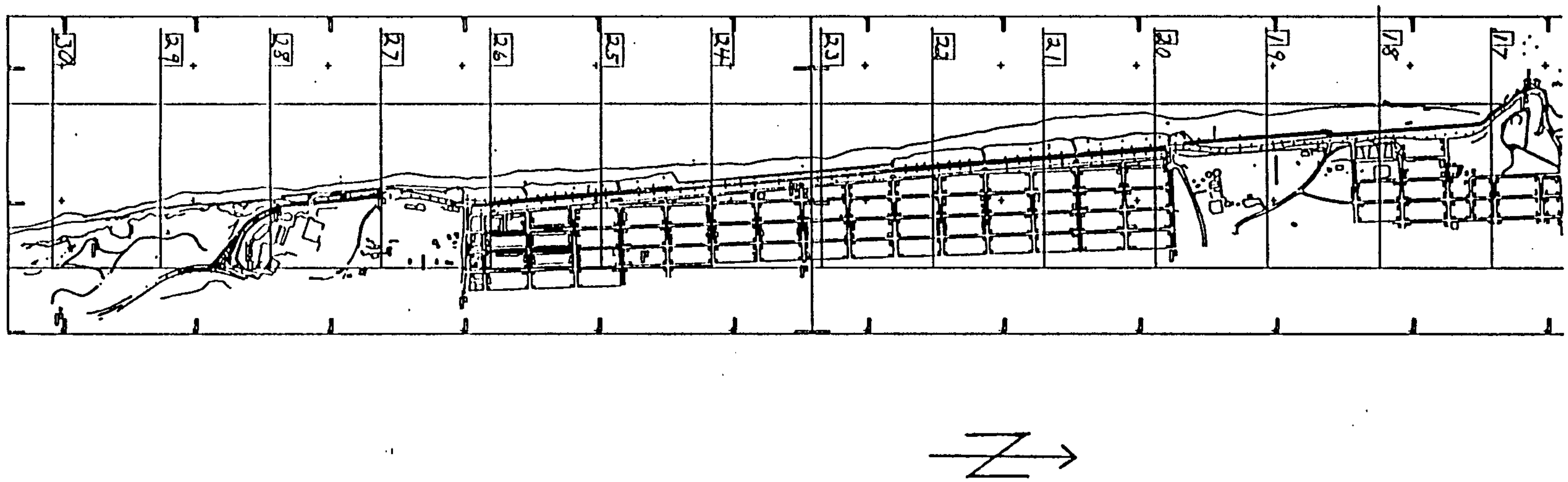
29	142	140	130	124	118	110	110	110	117	127	140	160	190	230	250	263	263
30	140	140	127	121	115	110	110	110	115	127	148	166	200	235	255	266	266
31	140	140	124	117	110	110	110	110	117	130	155	170	205	235	260	270	270
32	140	136	120	111	110	110	110	110	120	135	160	180	210	242	265	270	270
33	140	130	110	110	110	110	110	110	121	130	165	190	218	242	270	270	270
34	140	118	110	110	110	110	110	115	124	150	174	205	225	250	270	270	270
35	130	114	110	110	110	110	110	119	126	155	180	213	225	270	271	270	270
36	130	110	110	110	110	110	116	123	130	167	200	225	244	259	270	270	270
37	130	110	110	110	110	110	120	127	150	175	200	234	250	270	270	260	260
38	133	115	110	111	112	115	122	130	157	190	214	245	240	270	260	275	275
39	140	120	115	115	117	120	134	153	172	210	224	250	250	272	270	280	280
40	146	125	120	119	122	130	145	160	183	210	235	250	270	274	280	280	280
41	150	130	124	126	130	140	152	175	195	225	250	250	271	276	274	280	280
42	150	135	128	133	138	148	160	185	215	230	240	260	273	279	277	280	280
43	150	138	134	139	147	165	178	200	225	250	240	270	275	280	279	280	280
44	145	140	144	150	165	180	186	225	235	253	260	271	277	281	280	281	281
45	140	158	154	160	180	200	200	245	250	260	265	273	279	283	283	284	284
46	148	168	163	167	185	220	220	253	260	265	270	275	280	285	286	287	287
47	155	170	171	177	200	225	240	257	265	269	272	277	280	287	289	290	290
48	163	175	181	190	215	240	251	260	268	272	275	280	281	288	292	303	303
49	174	181	187	210	230	250	255	263	271	275	278	281	283	288	295	300	300
50	180	188	195	230	250	253	258	267	273	277	280	283	285	288	293	300	300
51	188	195	230	250	252	257	260	270	275	279	282	285	287	289	295	300	300
52	192	210	230	248	258	260	267	273	277	281	286	287	290	290	298	300	300
53	210	220	241	247	262	264	274	280	281	285	289	290	295	296	310	300	300

Columns run alongshore at 500m intervals, 1 at the northern end and 35 at the southern end. Rows run offshore at 250m intervals, 1 being nearest the beach and 53 being furthest offshore. Depths are in decimeters.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

RCP WAVE DEPTH GRID

PLATE 14

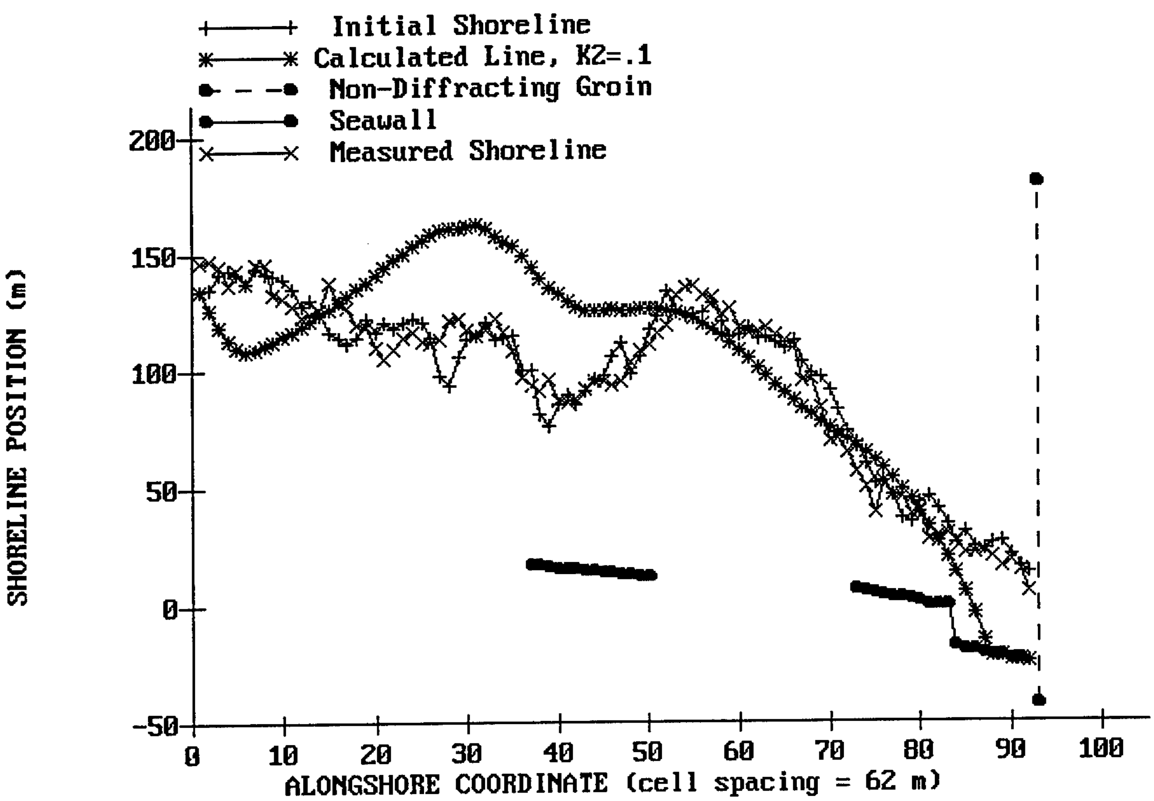


Numbered transects coincide with column numbers on depth grid and the alongshore coordinate in Plates 8 through 13.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

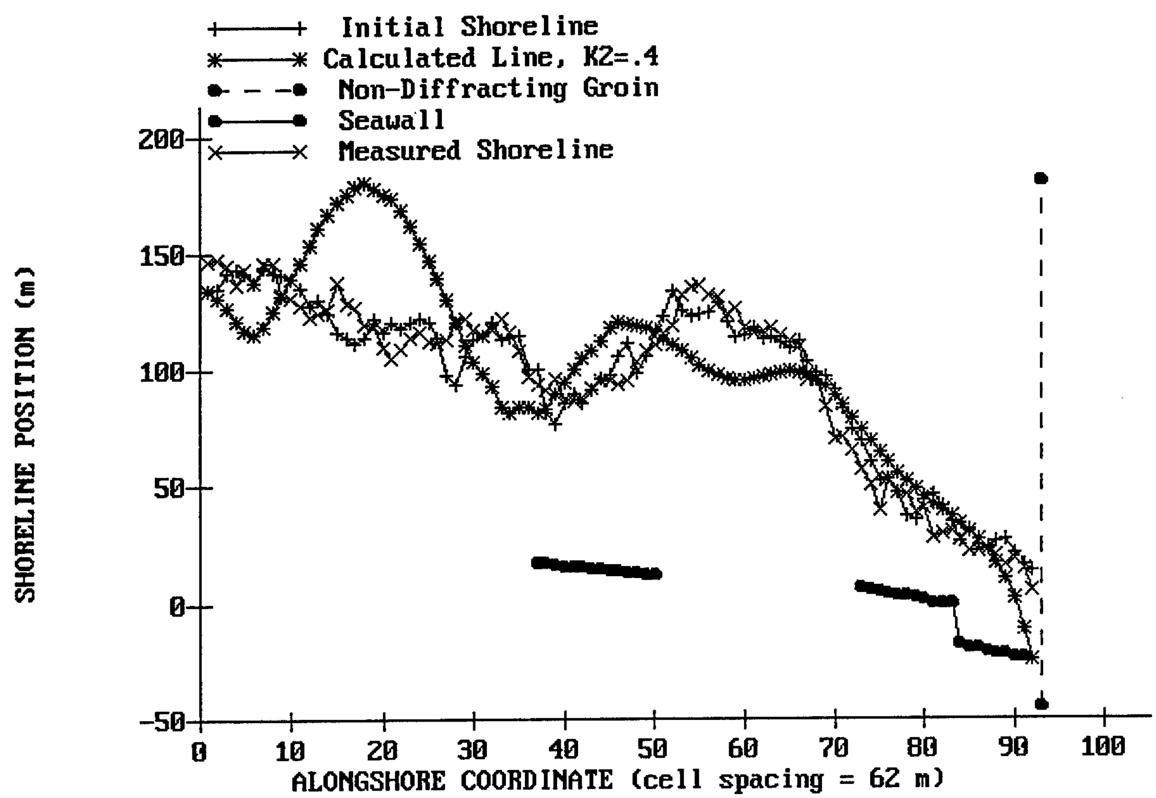
STUDY AREA

PLATE 15



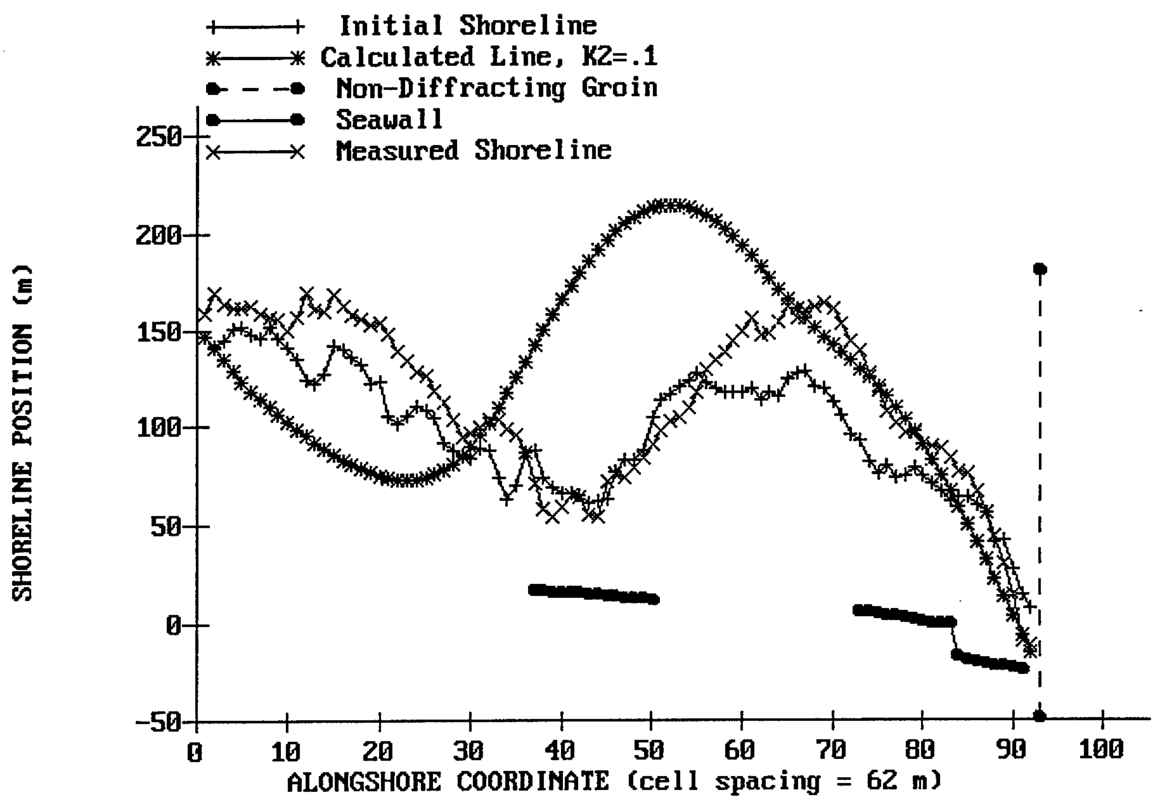
Run with WISWAVEi and rcp 45x87
grid data; 1970–71 data set;
k1=0.1 and k2=0.1

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
GENESIS
SHORELINE MODELING RESULTS
PLATE 16



Run with WISWAVi and rcp 45x87
grid data; 1970-71 data set;
k1=0.1 and k2=0.4

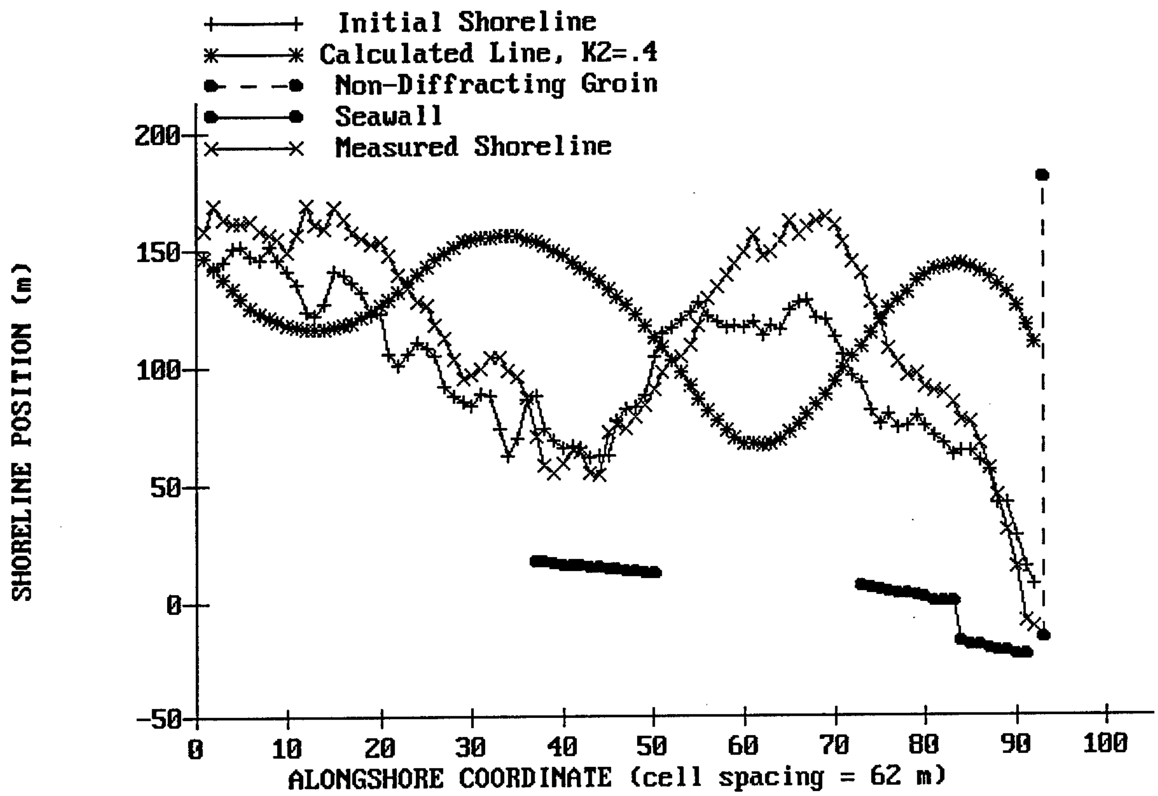
OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
GENESIS
SHORELINE MODELING RESULTS
PLATE 17



Run with WISWAVEii unaltered wave angles and rcp 45x87 grid data; 1980-85 data set; k1=0.1 and k2=0.1

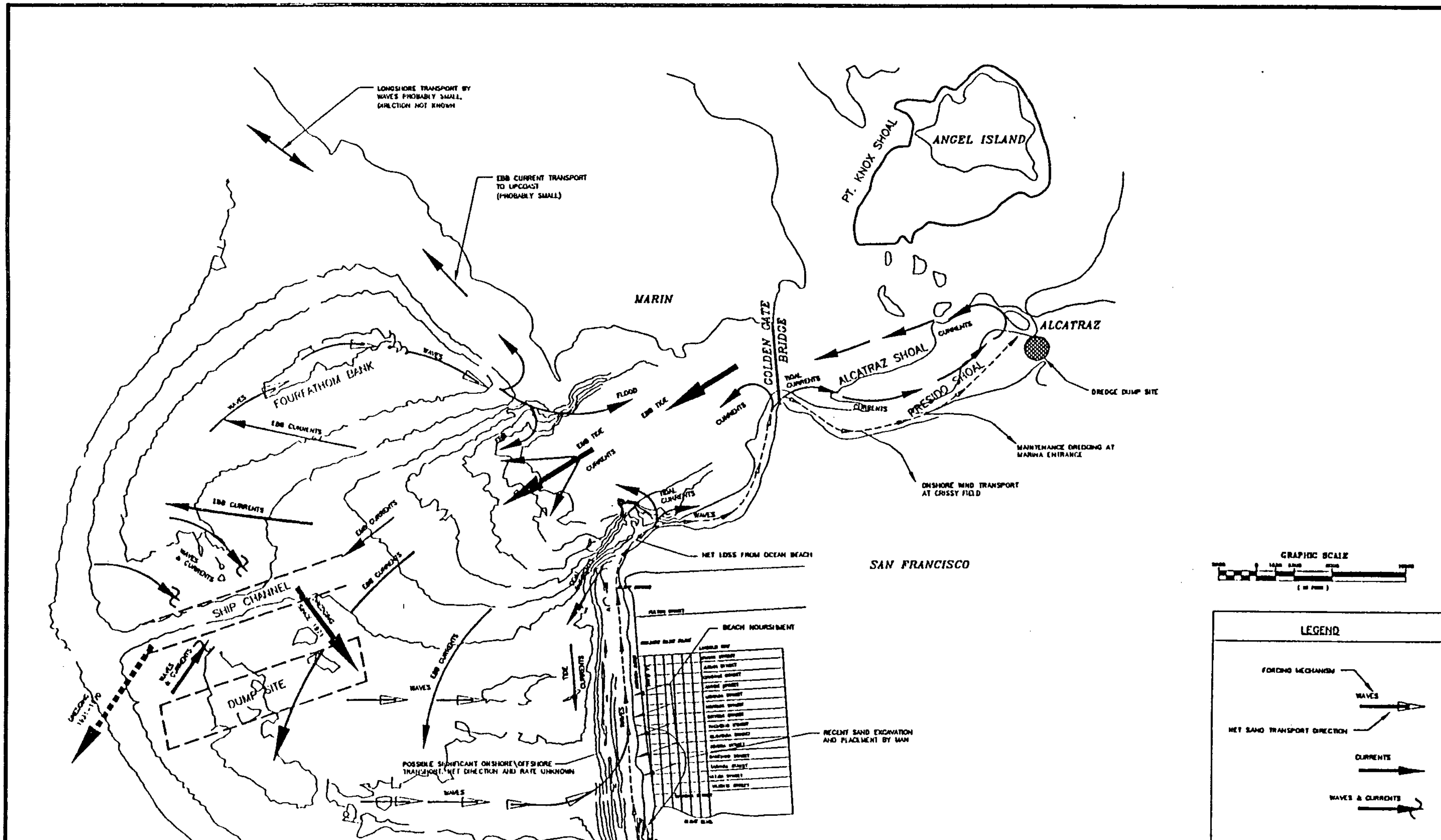
OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
GENESIS
SHORELINE MODELING RESULTS

PLATE 18



Run with WISWAVEii unaltered wave angles and rcp 45x87 grid data; 1980–85 data set; k1=0.1 and k2=0.4

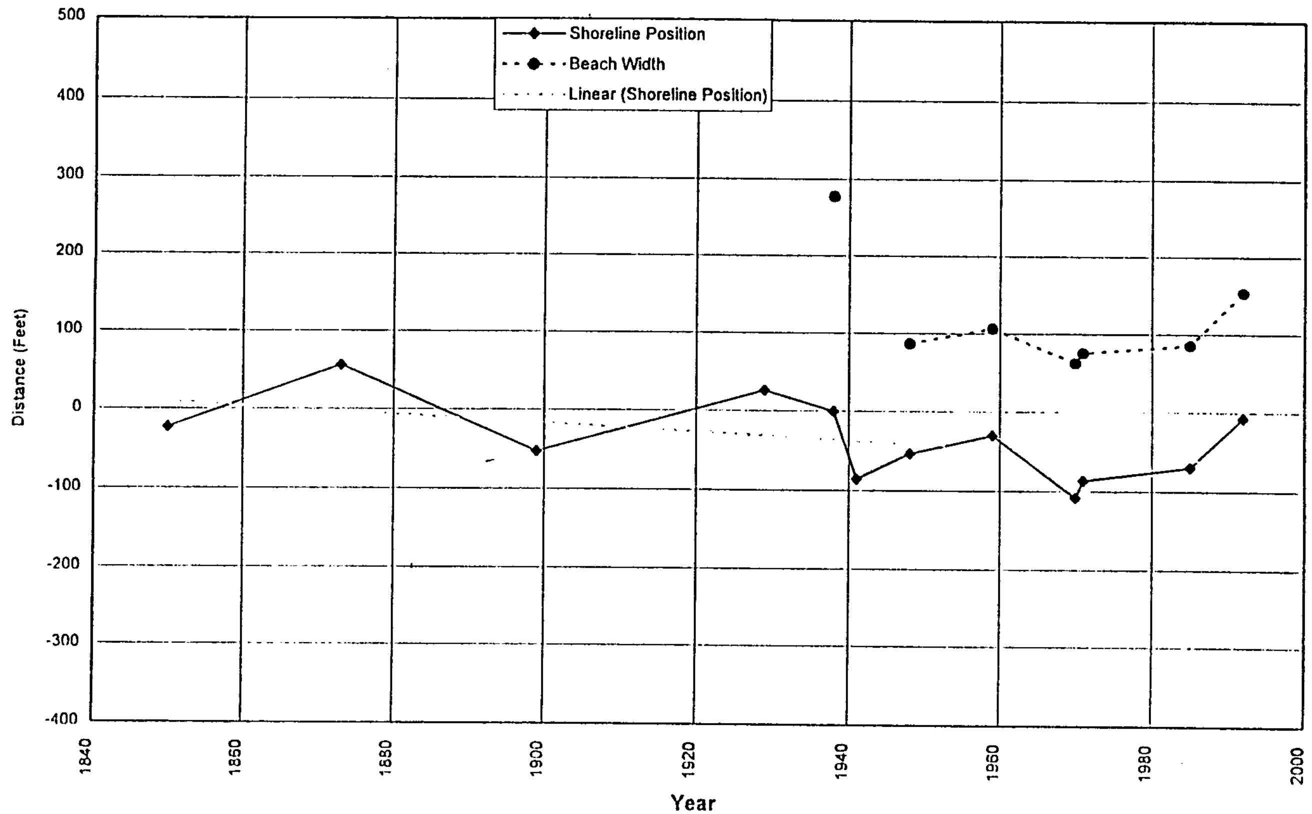
OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
GENESIS
SHORELINE MODELING RESULTS
PLATE 19



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

SEDIMENT TRANSPORT SCHEMATIC
(NET TRANSPORT SHOWN)

PLATE 20

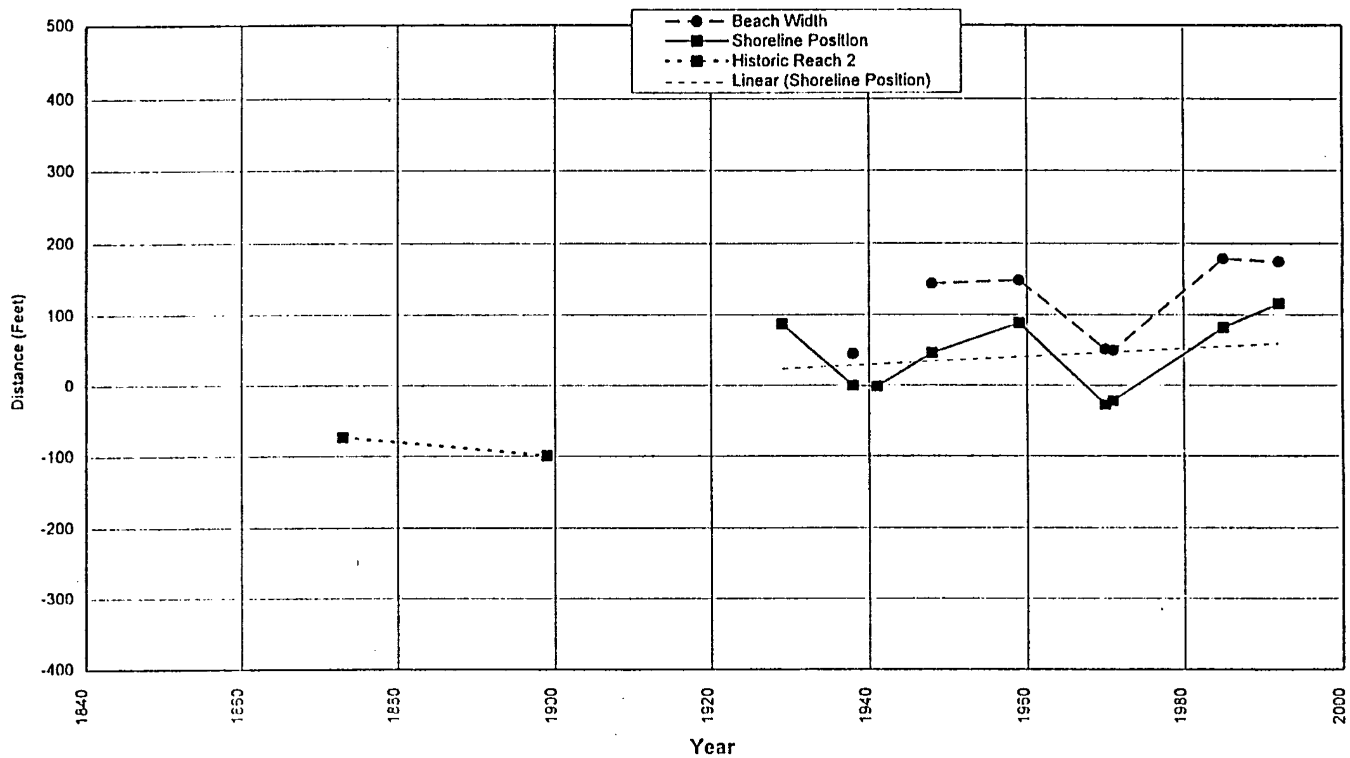


Note:
1. Shoreline position distances are relative to 1938 shoreline position.
2. Linear trends depicted for analysis purposes only. Linear trend is not intended as a predictor of future behavior.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

OCEAN BEACH REACH 1

PLATE 21



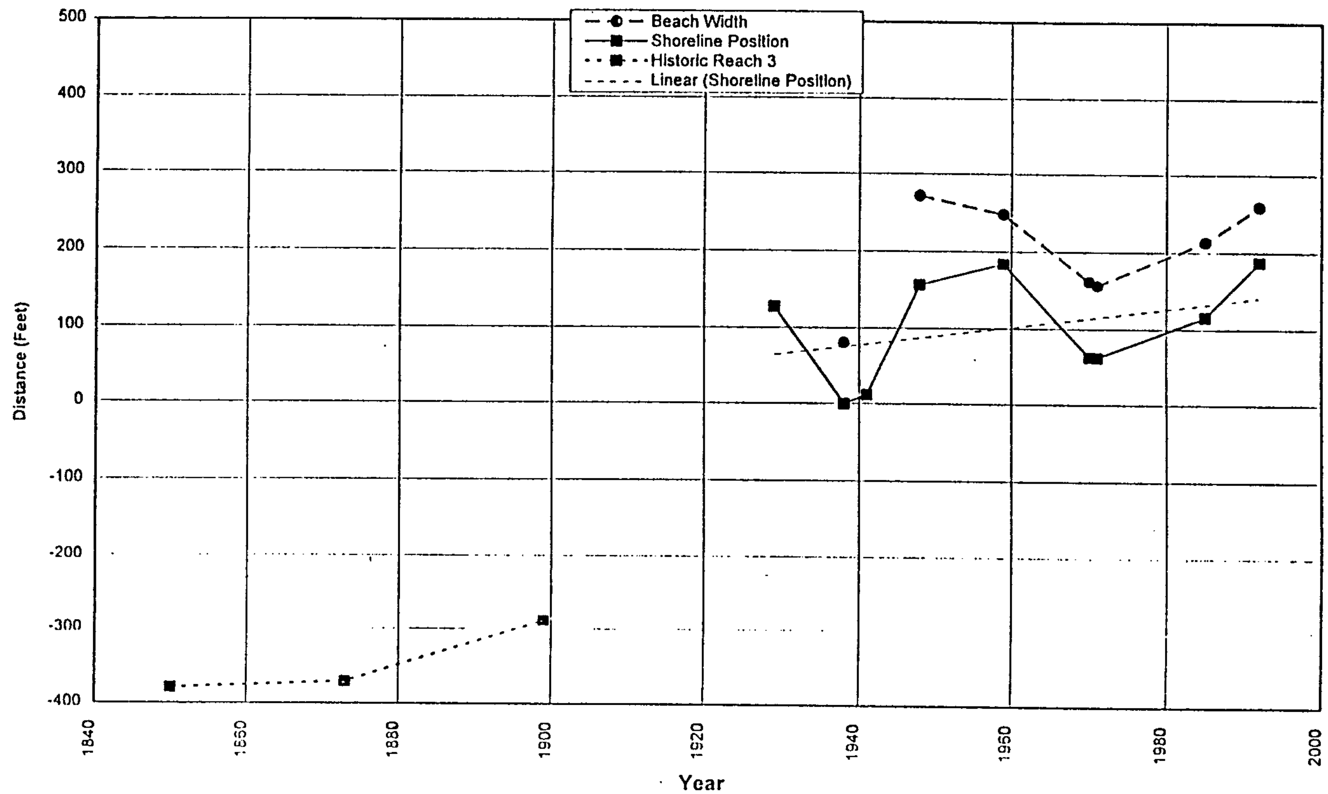
Note:

1. Shoreline position distances are relative to 1938 shoreline position.
2. Linear trends depicted for analysis purposes only. Linear trend is not intended as a predictor of future behavior.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

OCEAN BEACH REACH 2

PLATE 22



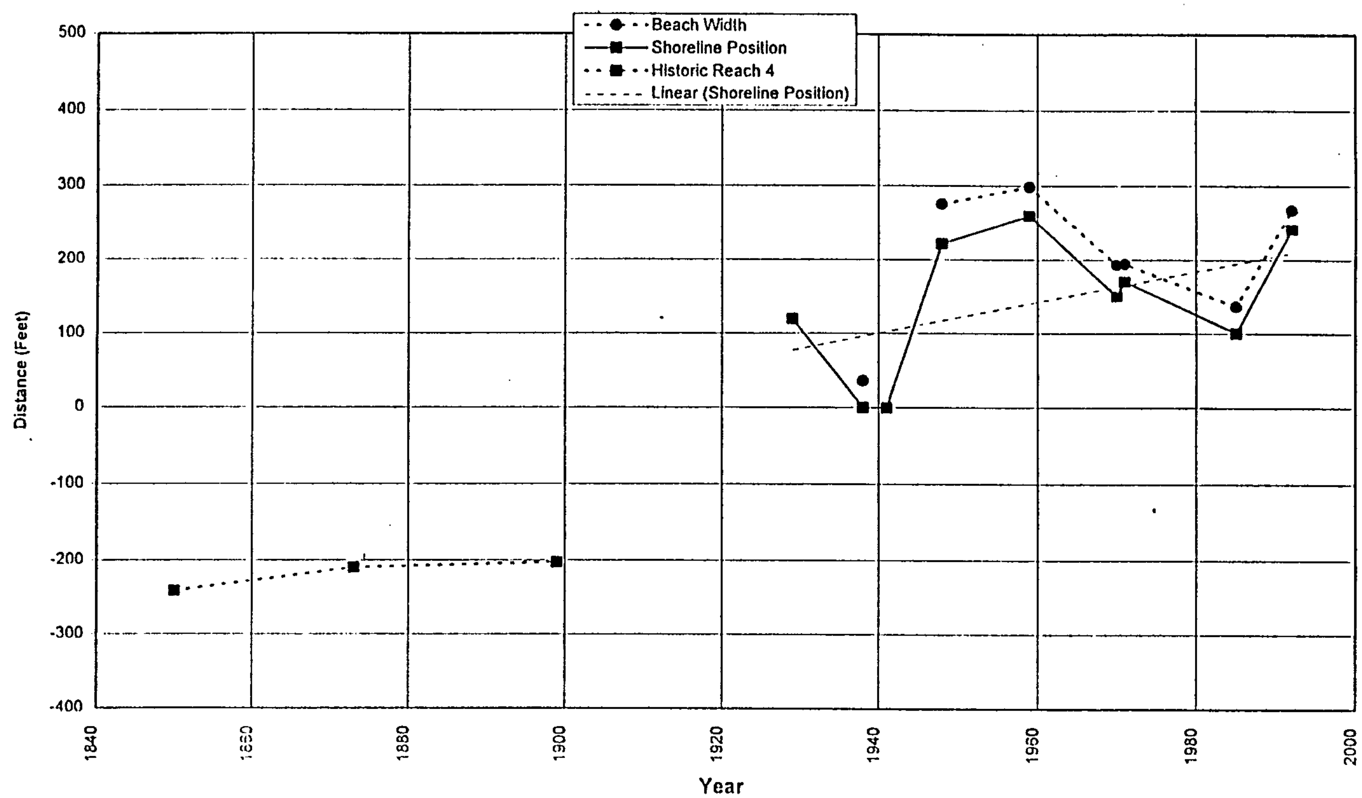
Note:

1. Shoreline position distances are relative to 1938 shoreline position.
2. Linear trends depicted for analysis purposes only. Linear trend is not intended as a predictor of future behavior.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

OCEAN BEACH REACH 3

PLATE 23

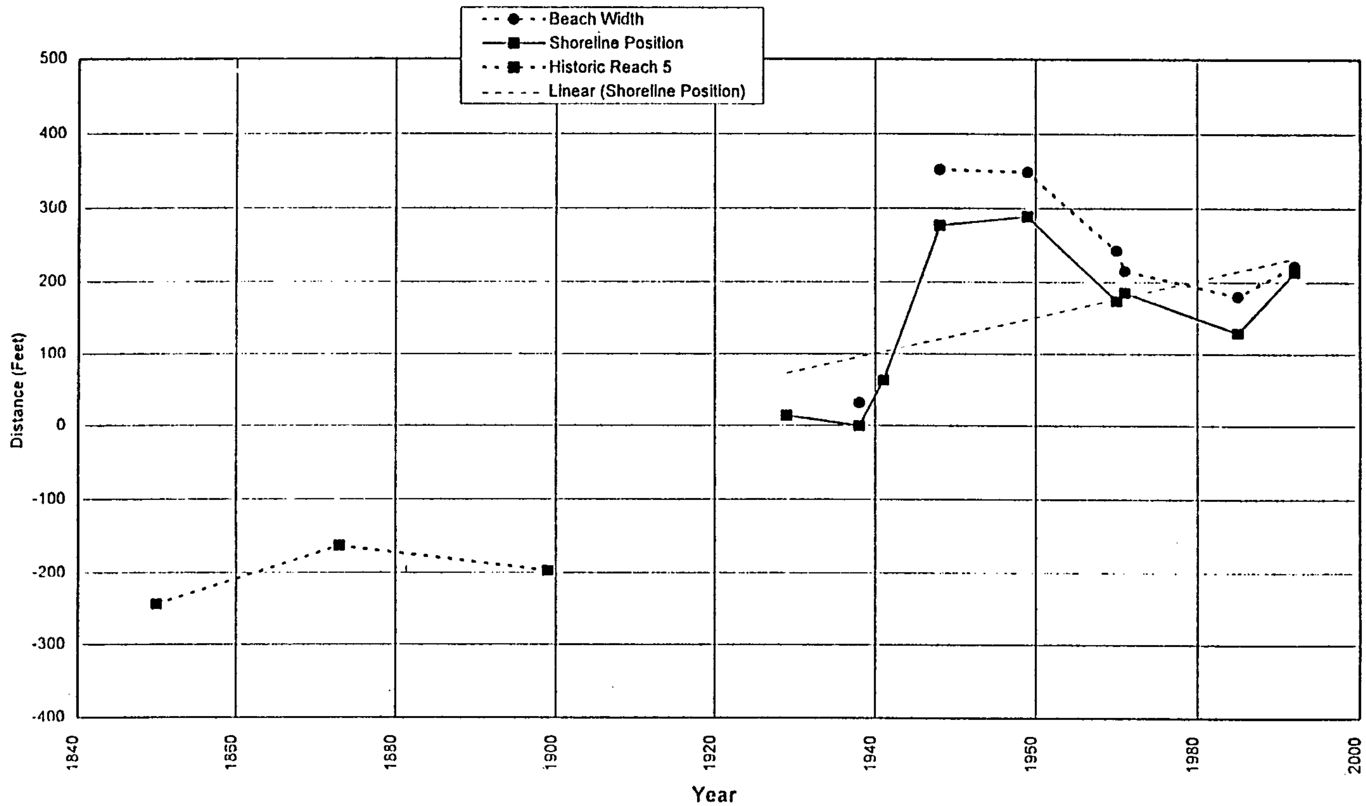


Note:
1. Shoreline position distances are relative to 1938 shoreline position.
2. Linear trends depicted for analysis purposes only. Linear trend is not intended as a predictor of future behavior.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

OCEAN BEACH REACH 4

PLATE 24

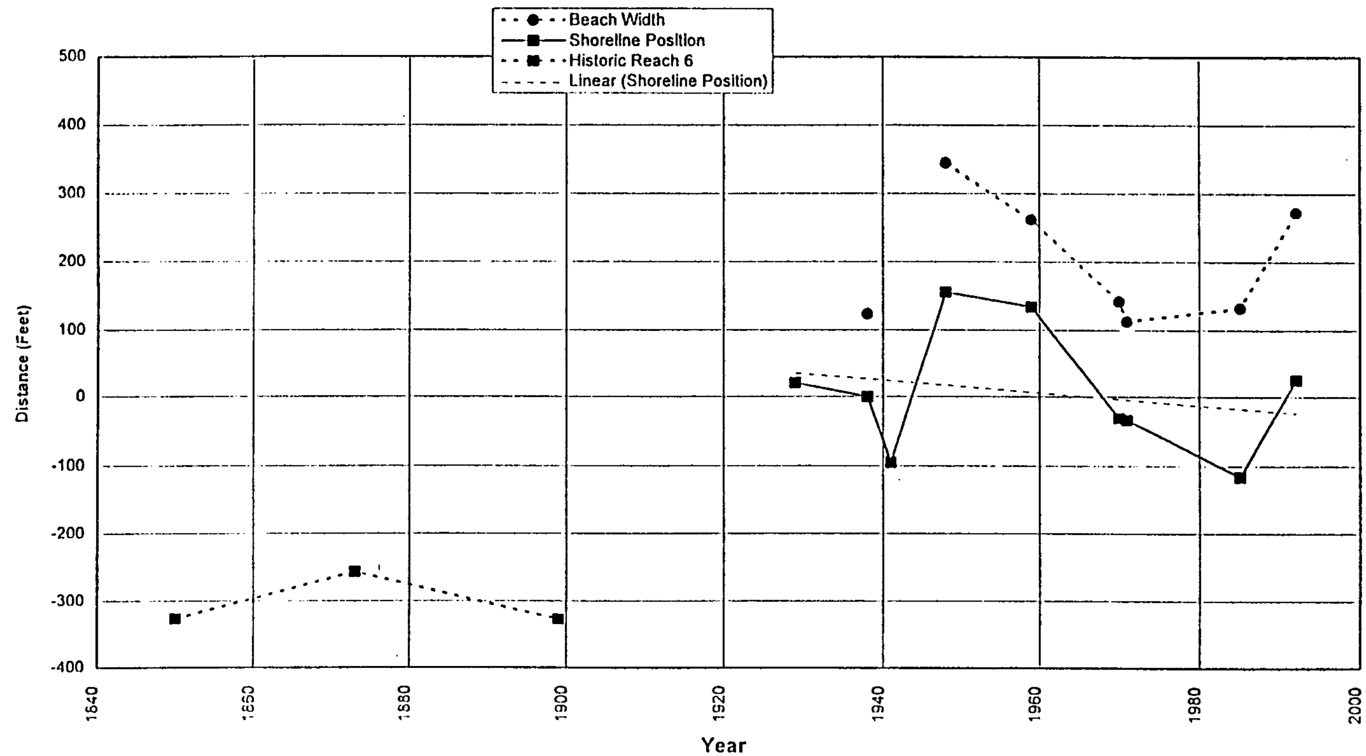


Note:
1. Shoreline position distances are relative to 1938 shoreline position.
2. Linear trends depicted for analysis purposes only. Linear trend is not intended as a predictor of future behavior.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

OCEAN BEACH REACH 5

PLATE 25

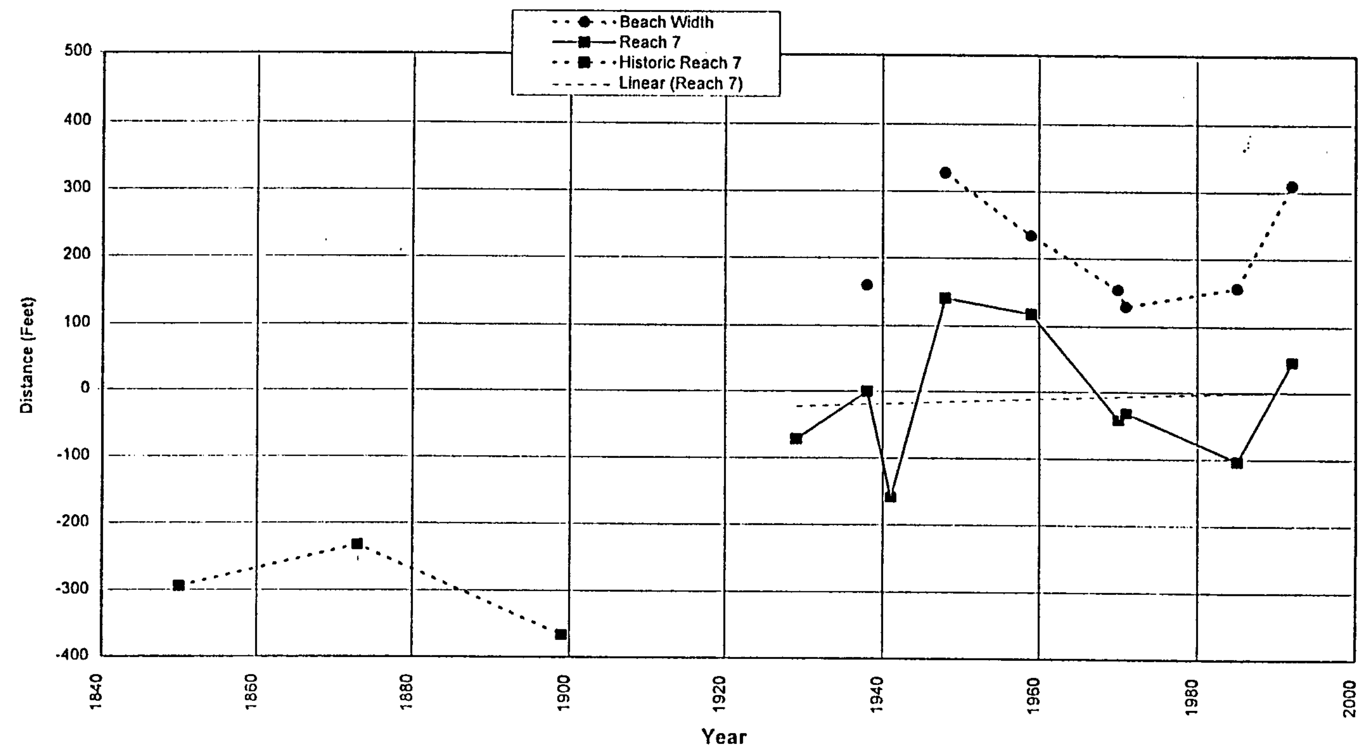


Note:
1. Shoreline position distances are relative to 1938 shoreline position.
2. Linear trends depicted for analysis purposes only. Linear trend is not intended as a predictor of future behavior.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

OCEAN BEACH REACH 6

PLATE 26



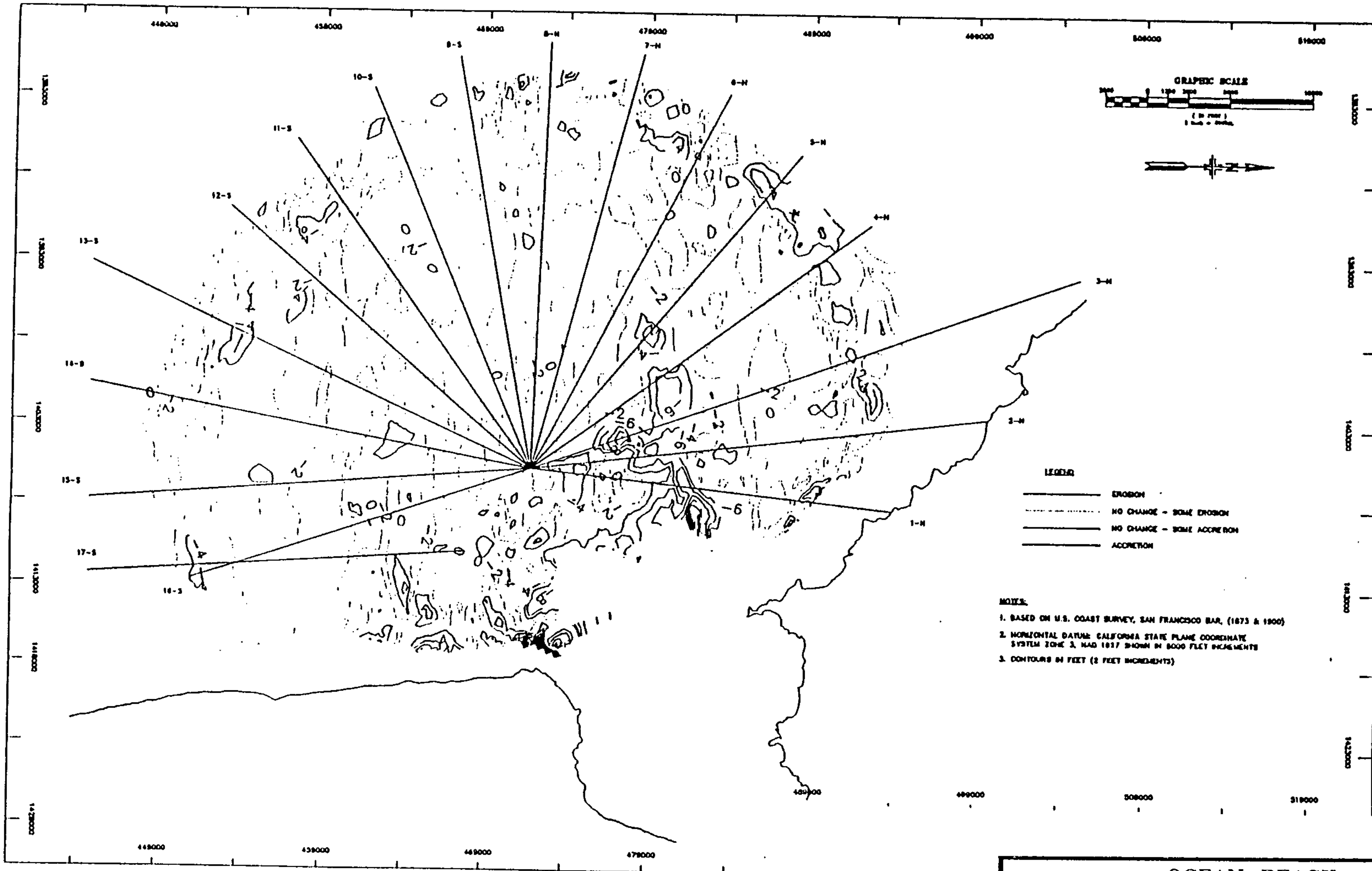
Note:

1. Shoreline position distances are relative to 1938 shoreline position.
2. Linear trends depicted for analysis purposes only. Linear trend is not intended as a predictor of future behavior.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

OCEAN BEACH REACH 7

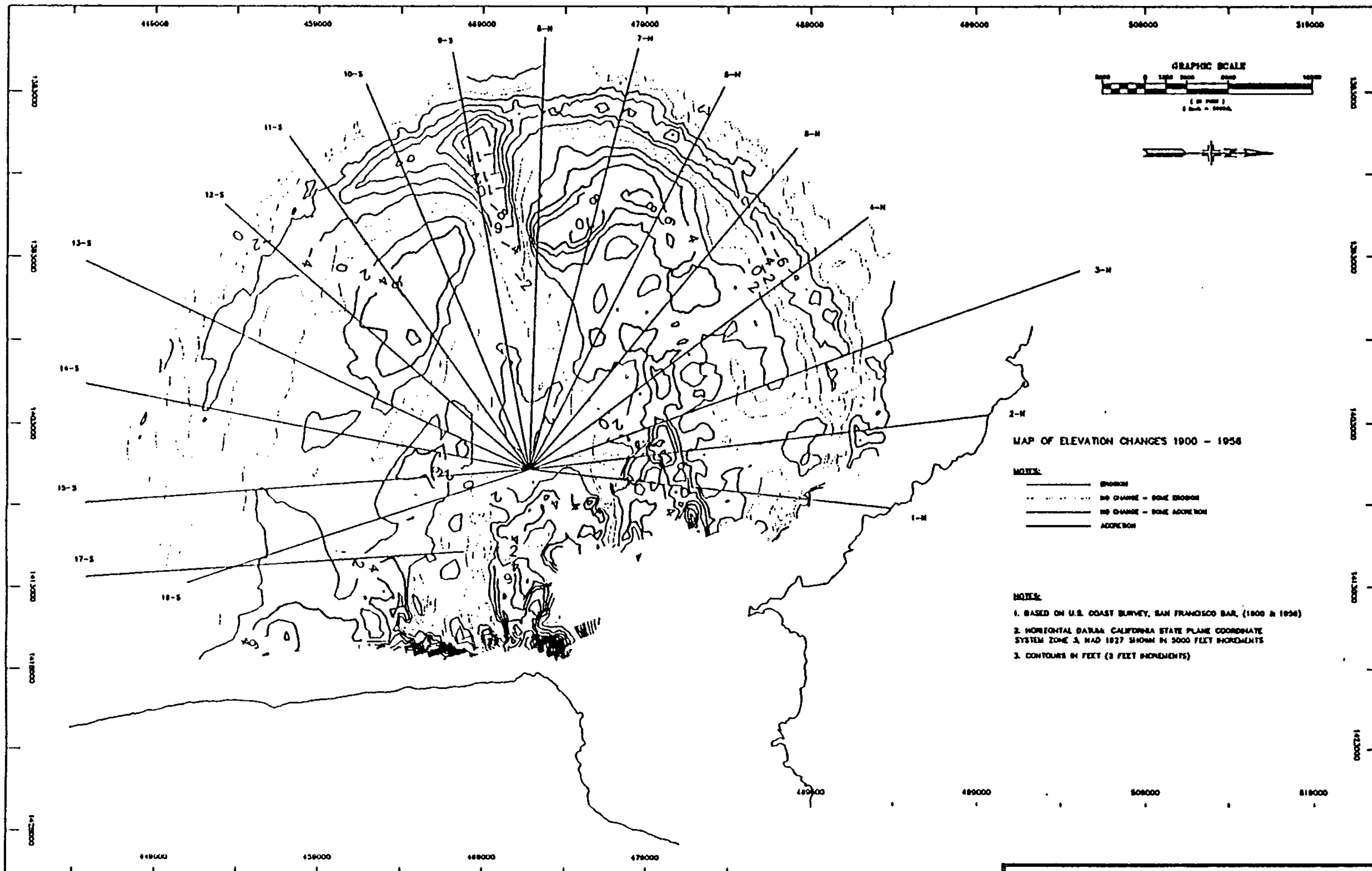
PLATE 27



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

MAP OF ELEVATION
CHANGES 1873–1900

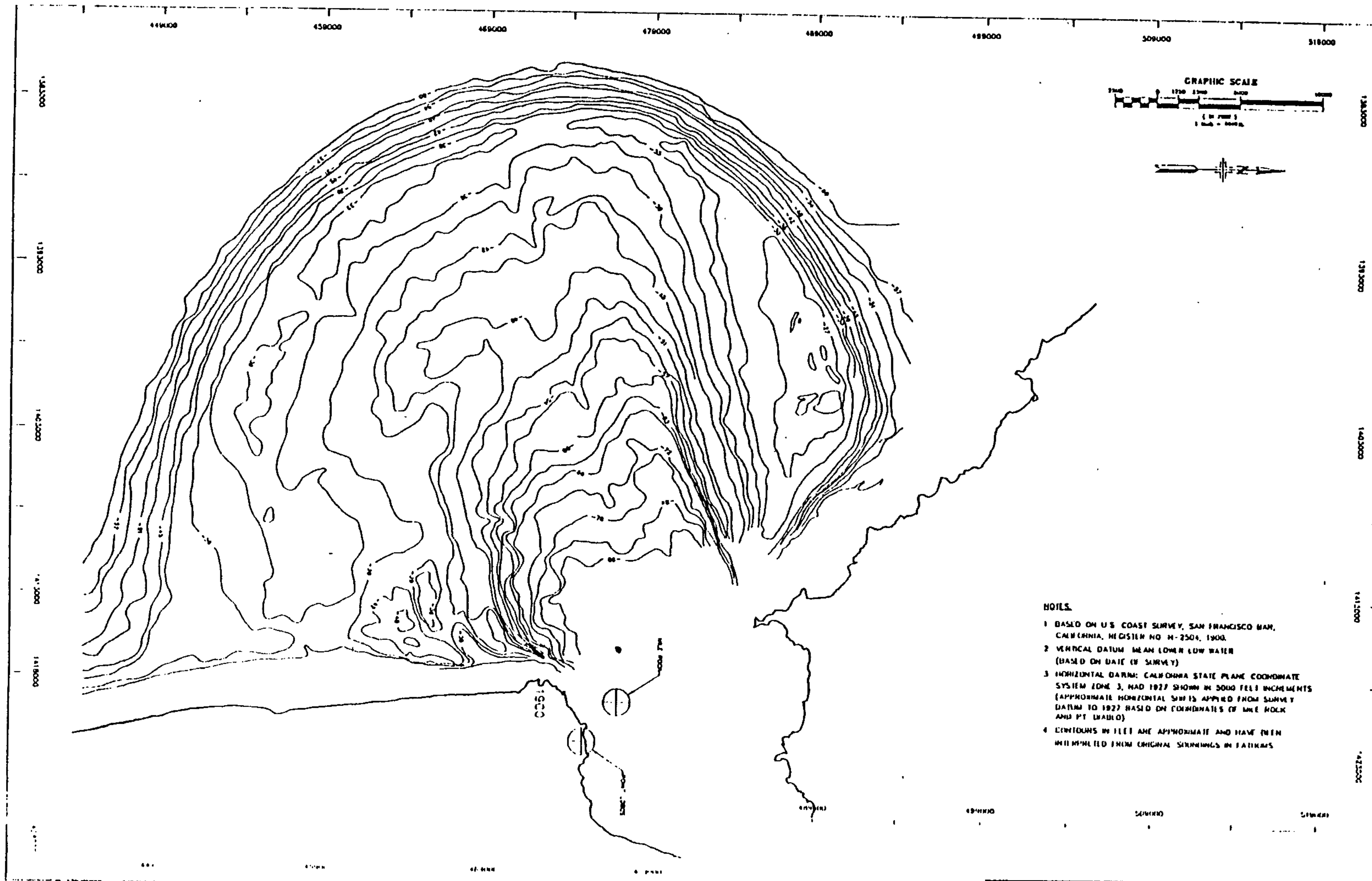
PLATE 28



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

MAP OF ELEVATION
CHANGES 1900–1956

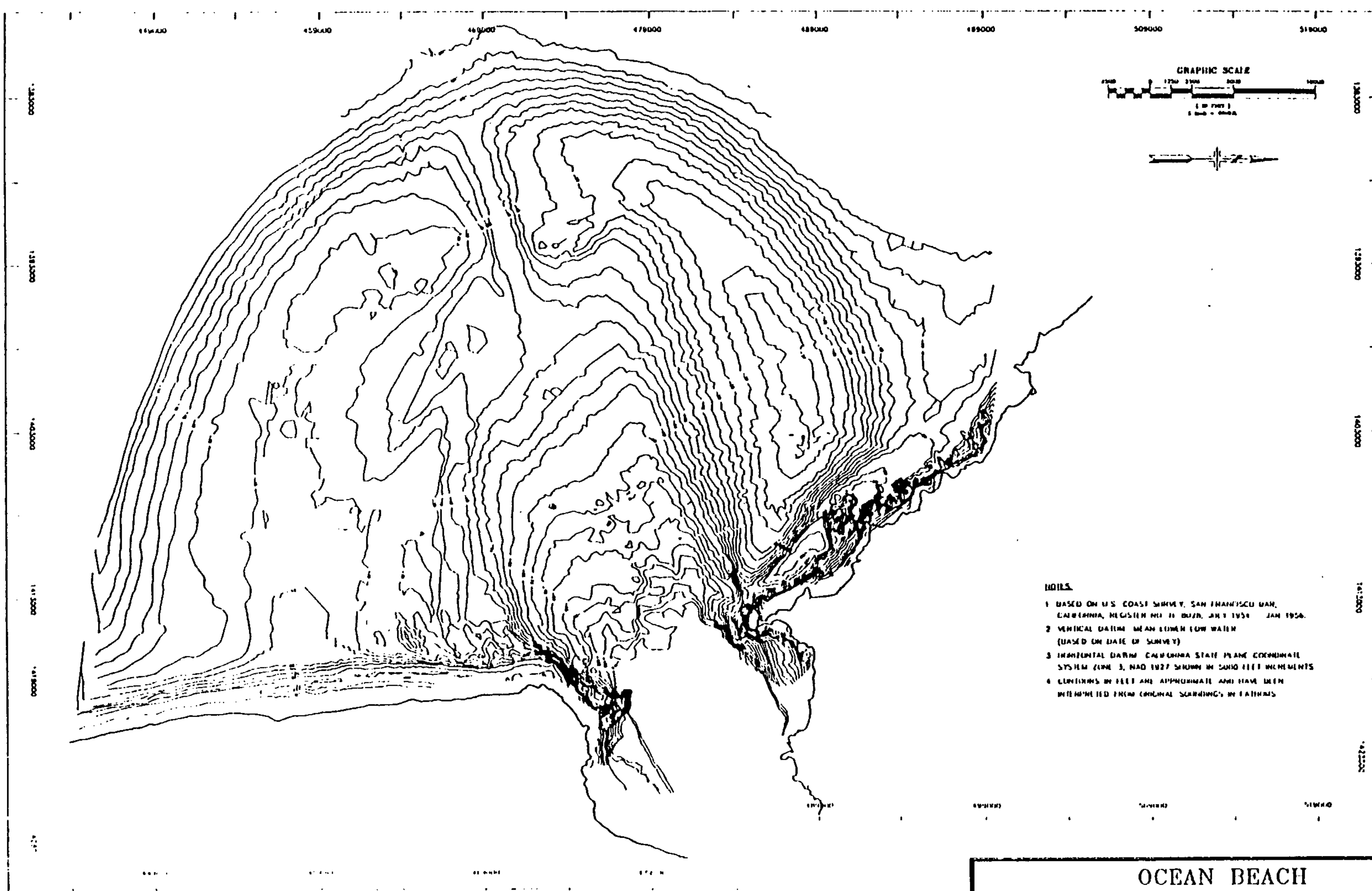
PLATE 29



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

1900 SURVEY

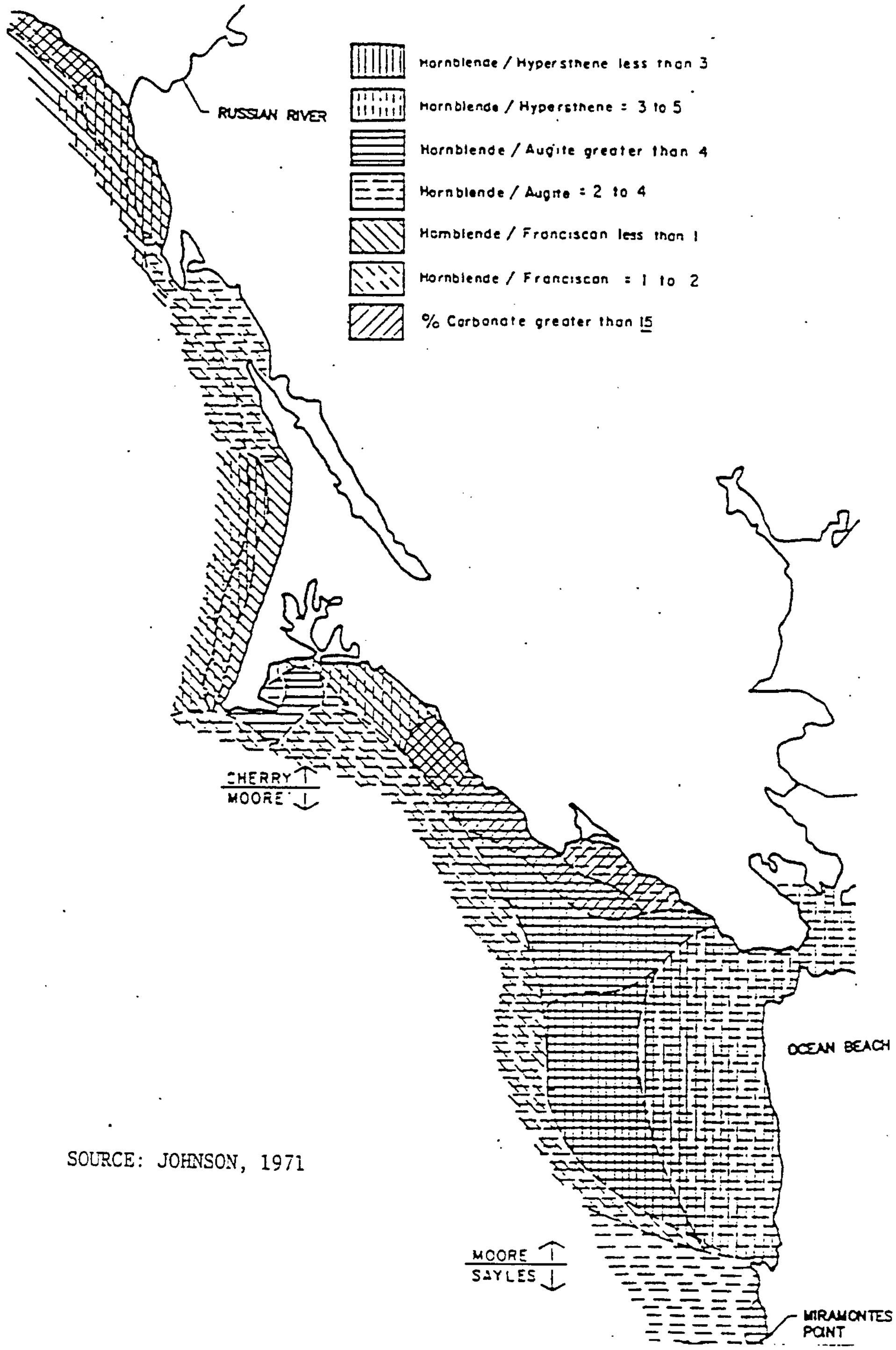
PLATE 30



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

1954–56 SURVEY

PLATE 31

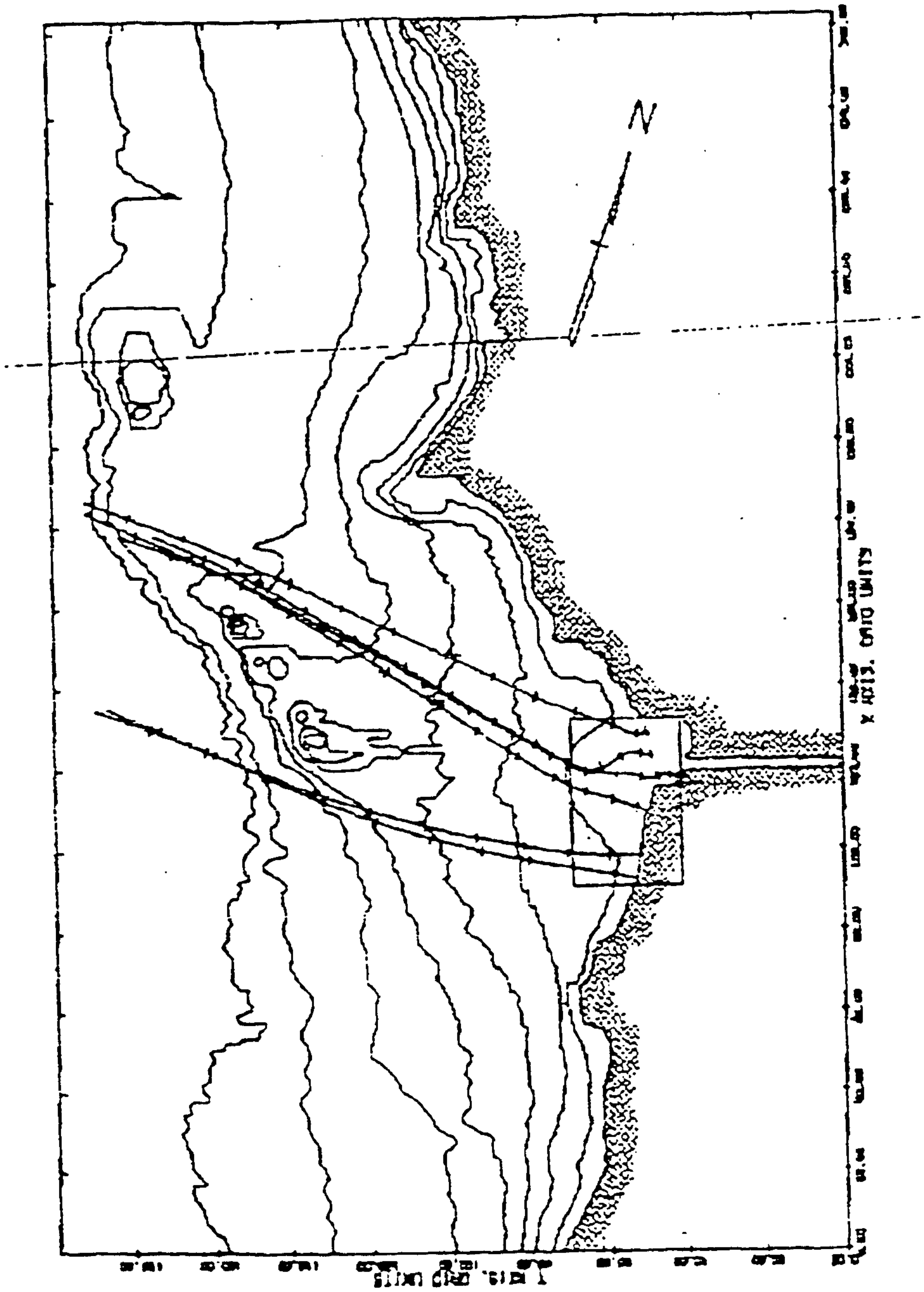


SOURCE: JOHNSON, 1971

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

HEAVY MINERAL DISTRIBUTION

PLATE 32

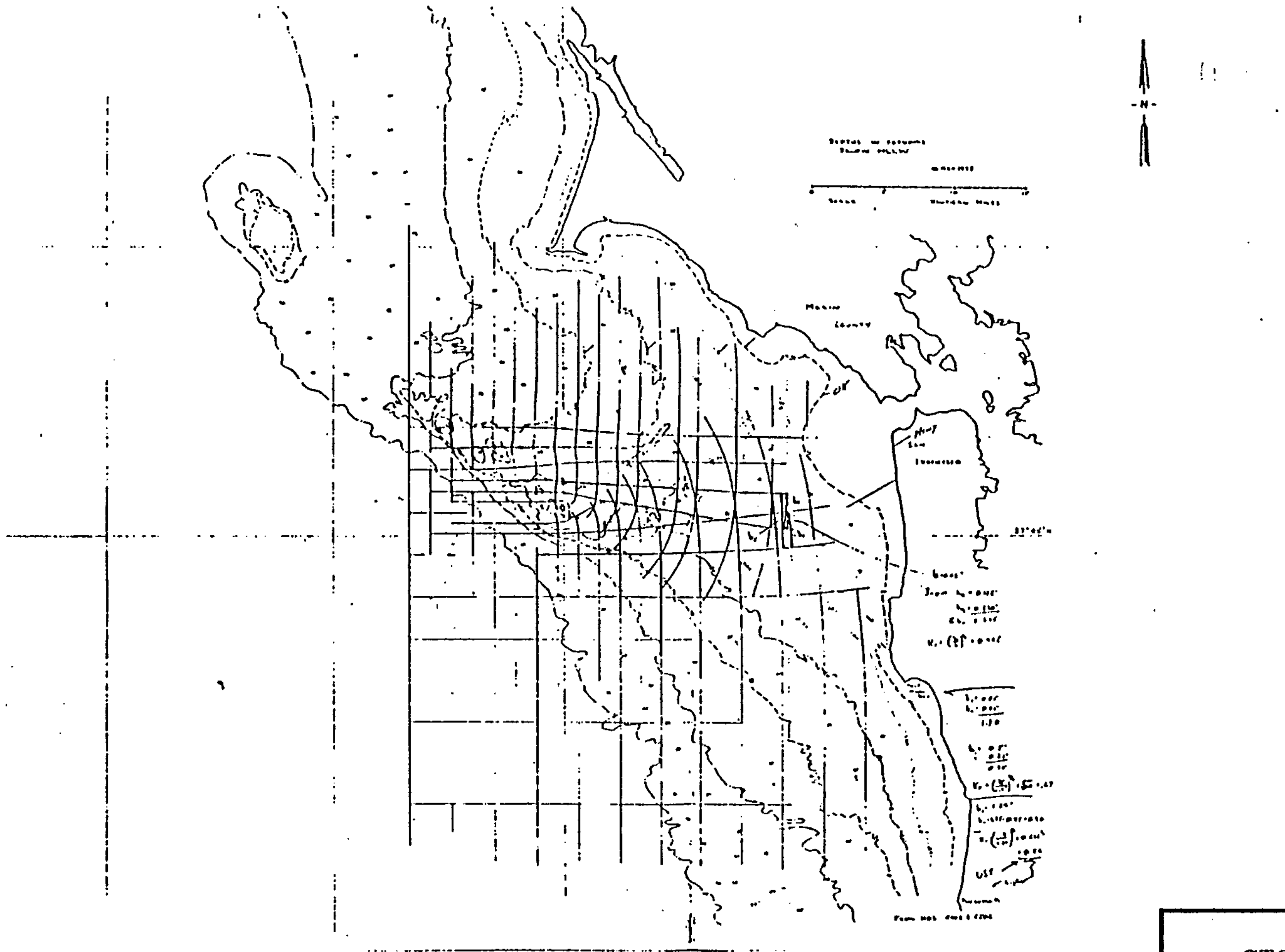


Source: Mogel, Street, & Perry (1970)

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

WAVE REFRACTION PAST
FARALLON ISLANDS

PLATE 33



Source: Woodward Clyde Consultants, 1978.

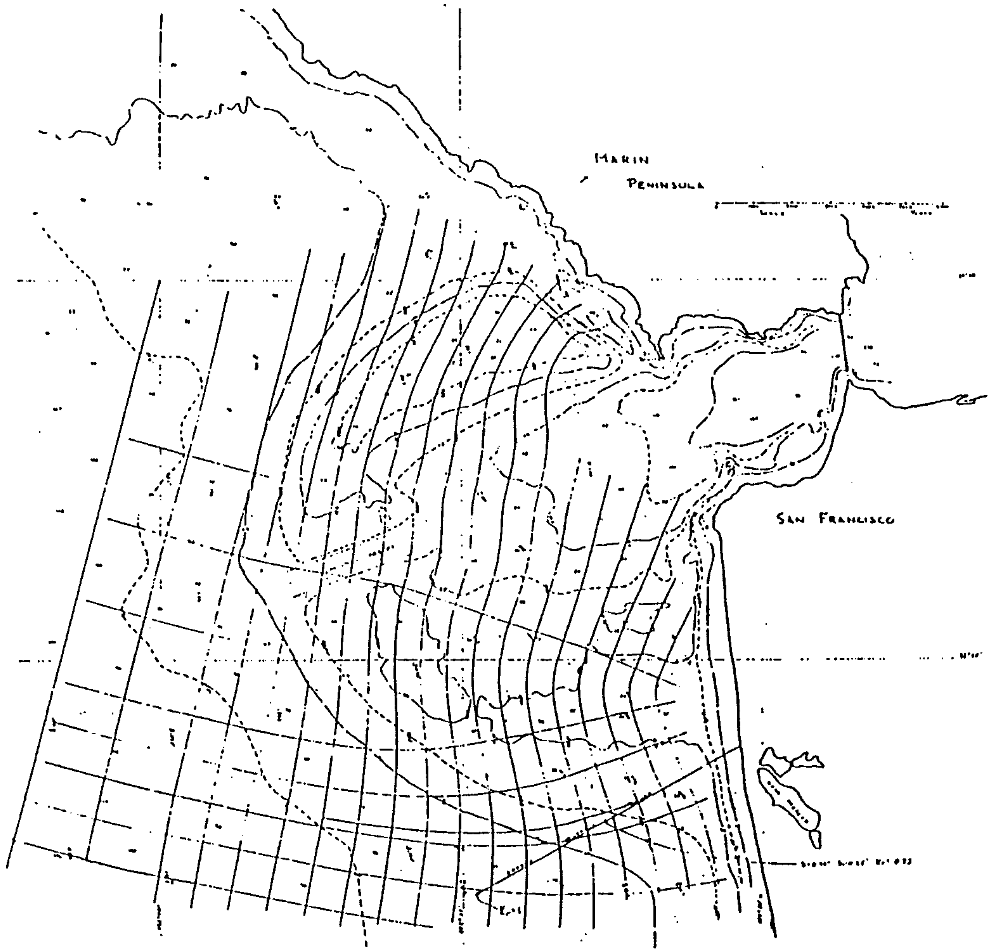
WAVE REFRACTION STUDY
$\theta = 270°$ $T = 10$ SECONDS

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

WAVE REFRACTION

PAST FARALLON ISLANDS

PLATE 34



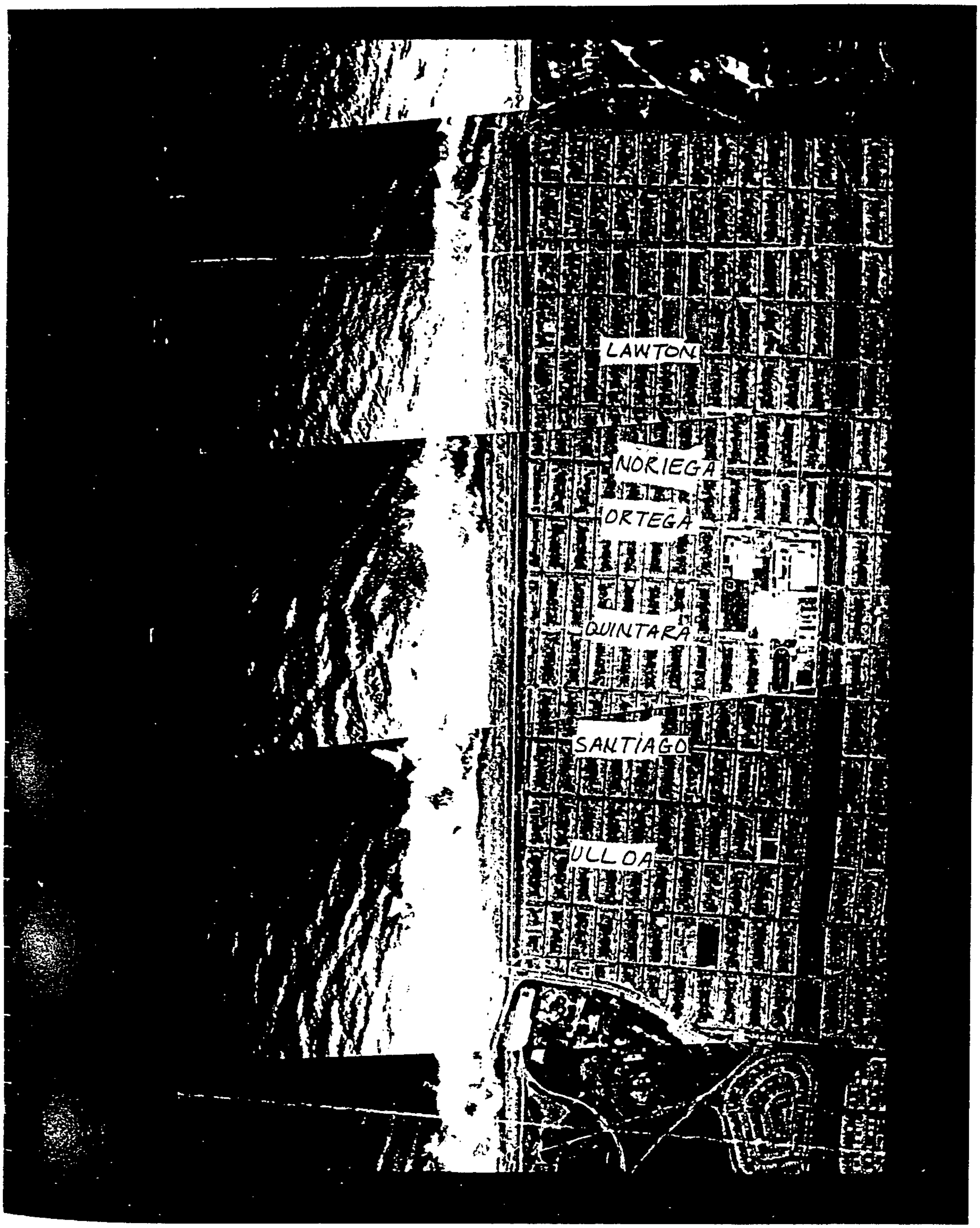
Source: Woodward Clyde Consultants, 1978.

WAVE REFRACTION STUDY
θ = 285° T = 10 SECONDS

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

WAVE REFRACTION
OVER SAN FRANCISCO BAR

PLATE 35

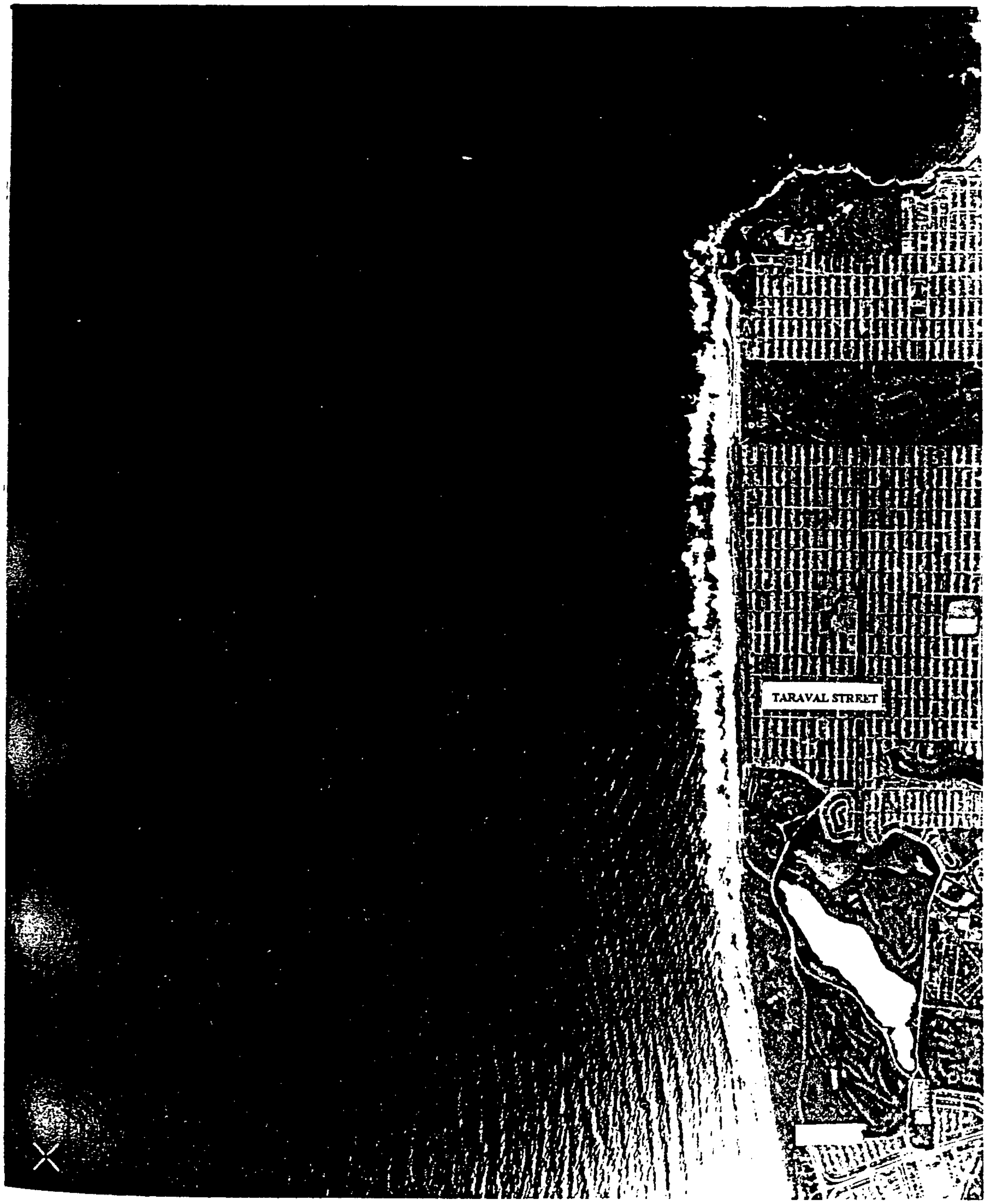


OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

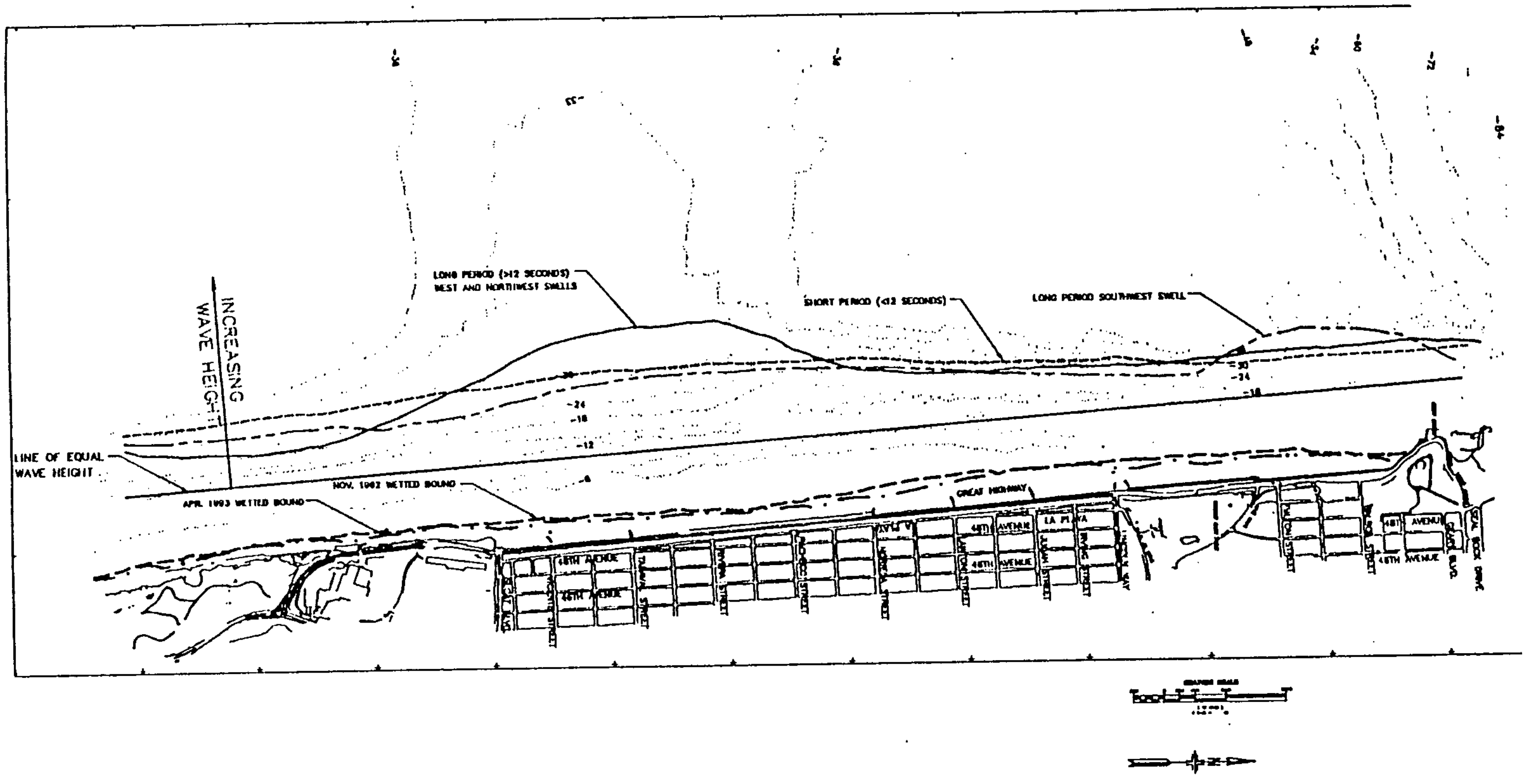
WAVE PATTERNS

SOUTH OF O'SHAUGHNESSY SEAWALL

PLATE 36



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
WAVE PATTERNS
STUDY AREA
PLATE 37

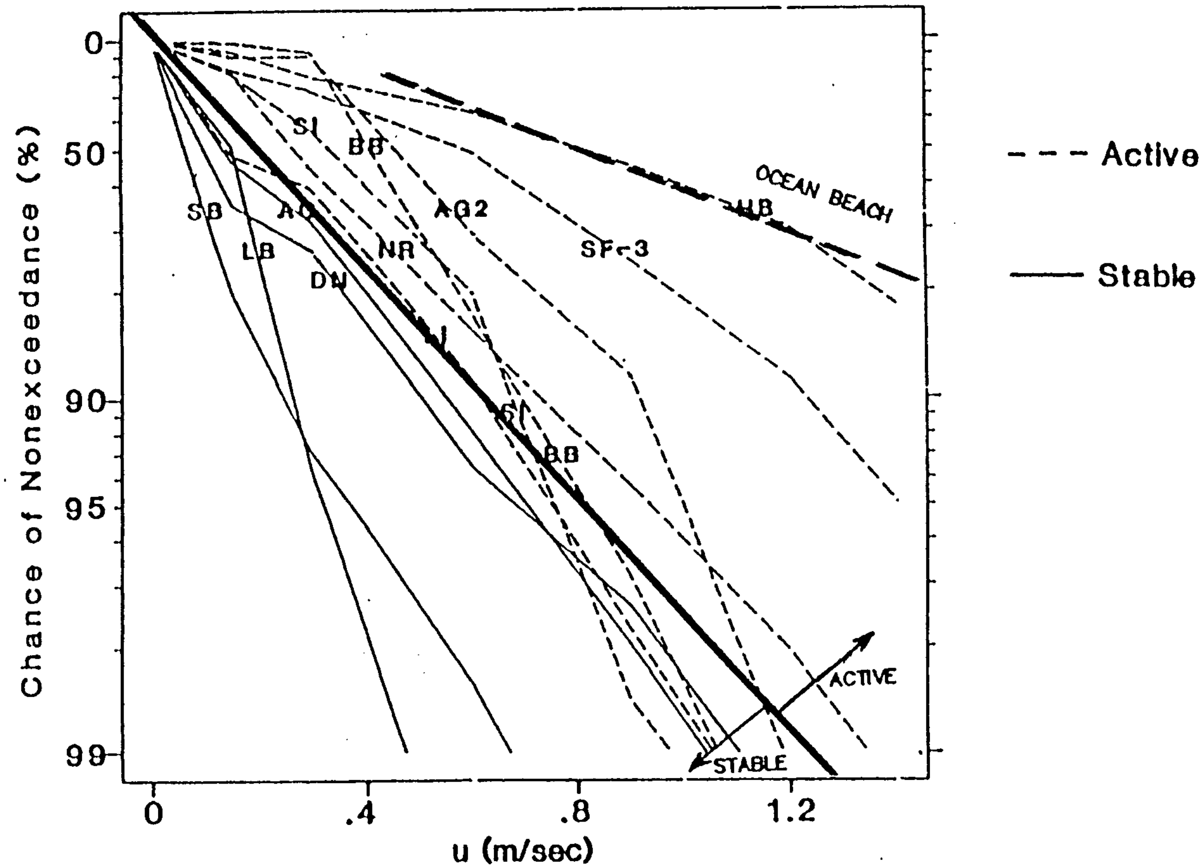


1. GRID SHOWN IS CALIFORNIA STATE PLANE COORDINATE SYSTEM ZONE 3, NAD 1927.
2. DEPTH CONTOURS (FT) SHOWN BASED ON MEAN LOWER LOW WATER, FROM 1954 – 1956 HYDROGRAPHIC SURVEY.
3. PLANIMETRIC MAP OBTAINED FROM HAMMON, JENSEN & WALLEN, NOVEMBER 1992.

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

TYPICAL BREAKING WAVE
HEIGHT DISTRIBUTION

PLATE 38



Chance of maximum wave induced near-bed velocity (u_{dmax}) being $< u$

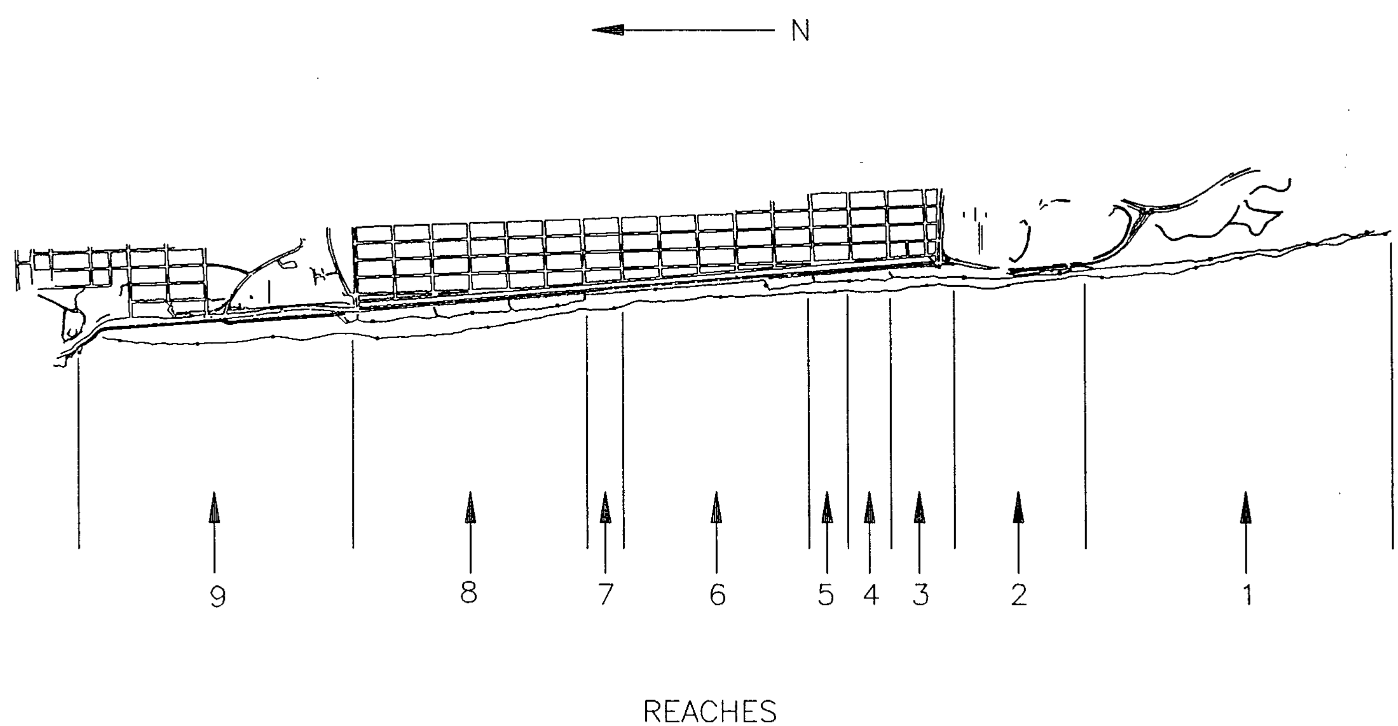
Site	
Long Branch, NJ	LB
Dam Neck, NC	DN
Atlantic City, NJ	AC
Santa Barbara, CA	SB
Sand Island, AL	SIM
Long Island, NY	LI
Brazos, TX	BB
New River, NC	NR
Silver Strand, CA	AG2
Humboldt, CA	HB
Humboldt, CA	SF3

SOURCE: HANDS, E.B. AND ALLISON, M.C. (1991)

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

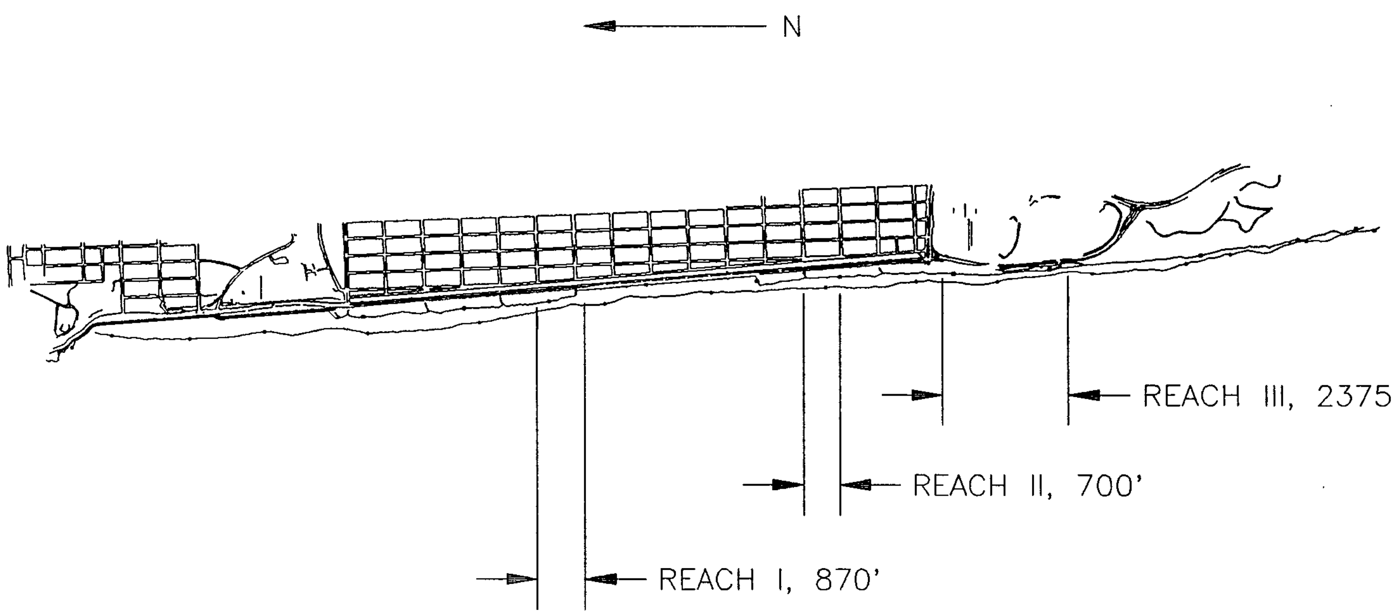
POTENTIAL FOR
ONSHORE-OFFSHORE MOVEMENT

PLATE 39



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
REACHES ESTABLISHED FOR
EROSION STUDY BY D. SAND

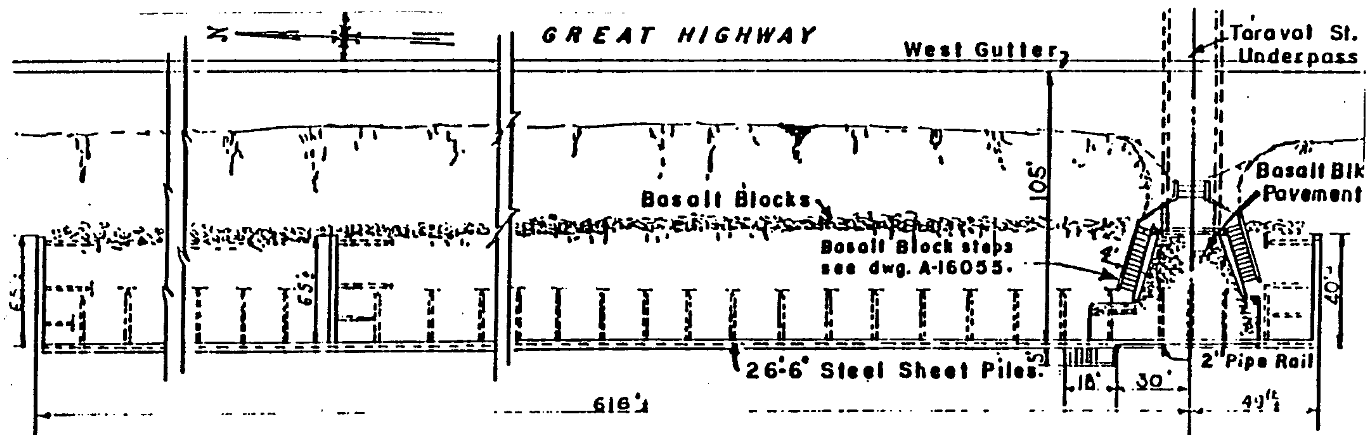
PLATE 40



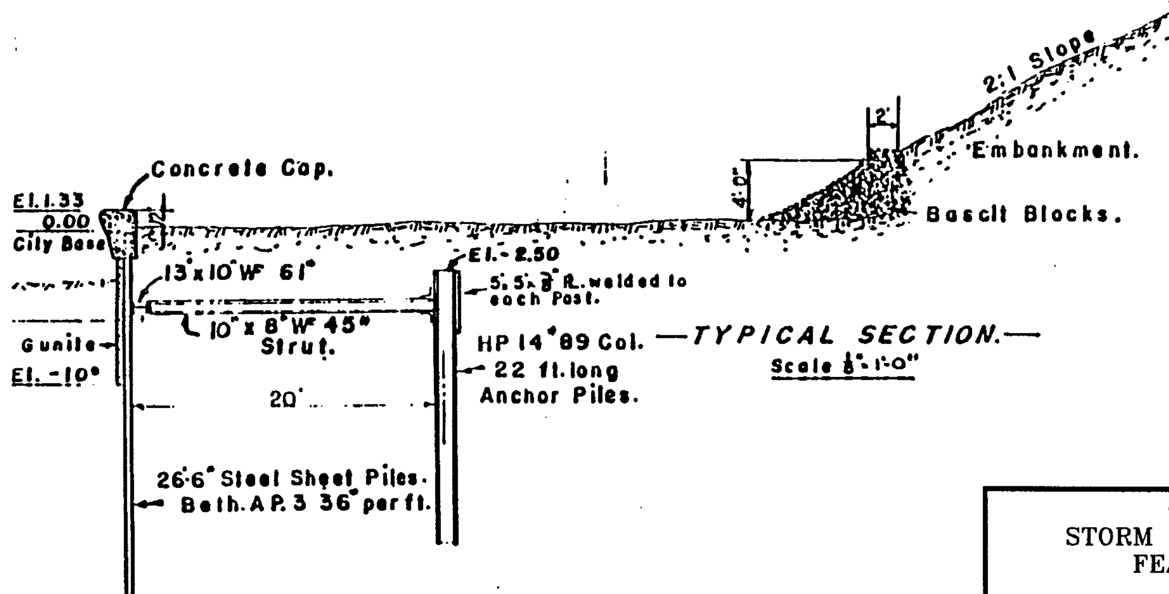
OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

REACHES SELECTED
FOR FURTHER STUDY

PLATE 41



—LOCATION PLAN—
SCALE 1"=50'

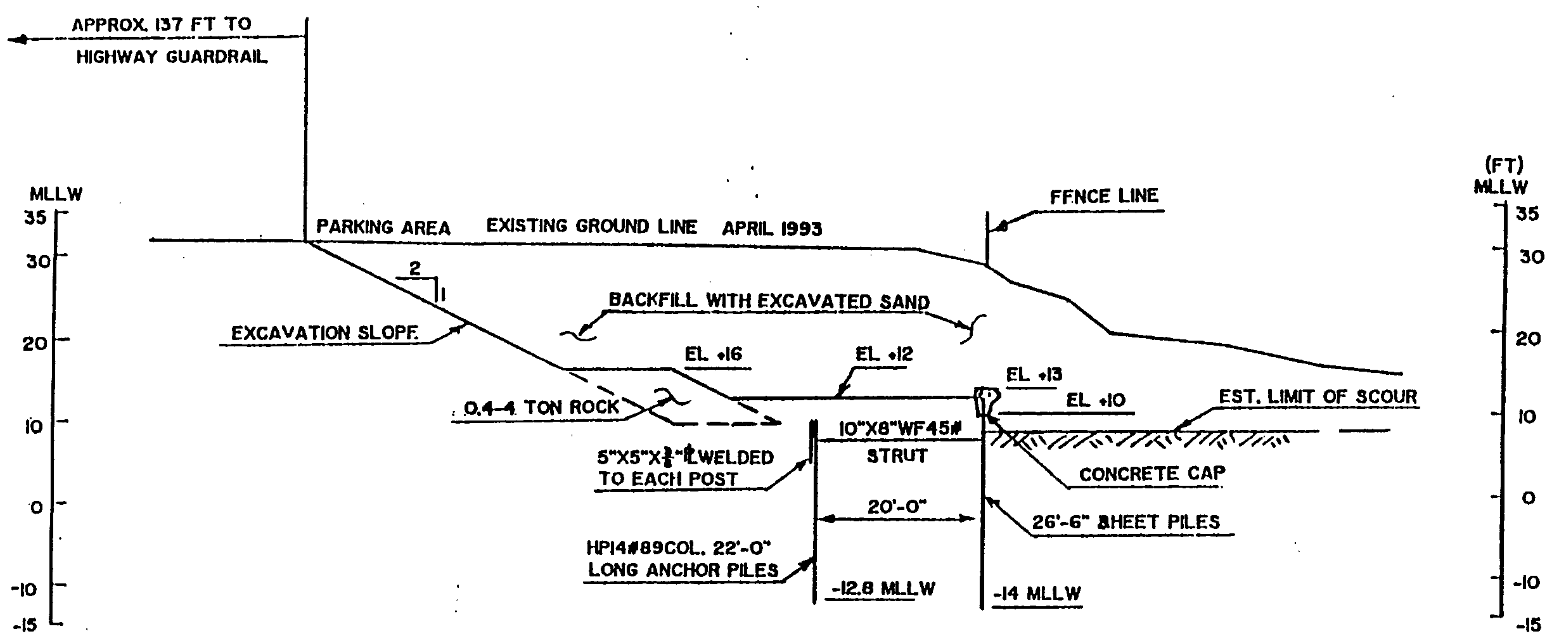


—TYPICAL SECTION.—
Scale ⅛"=1'-0"

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

TARAVAL STREET BULKHEAD
AT GREAT HIGHWAY

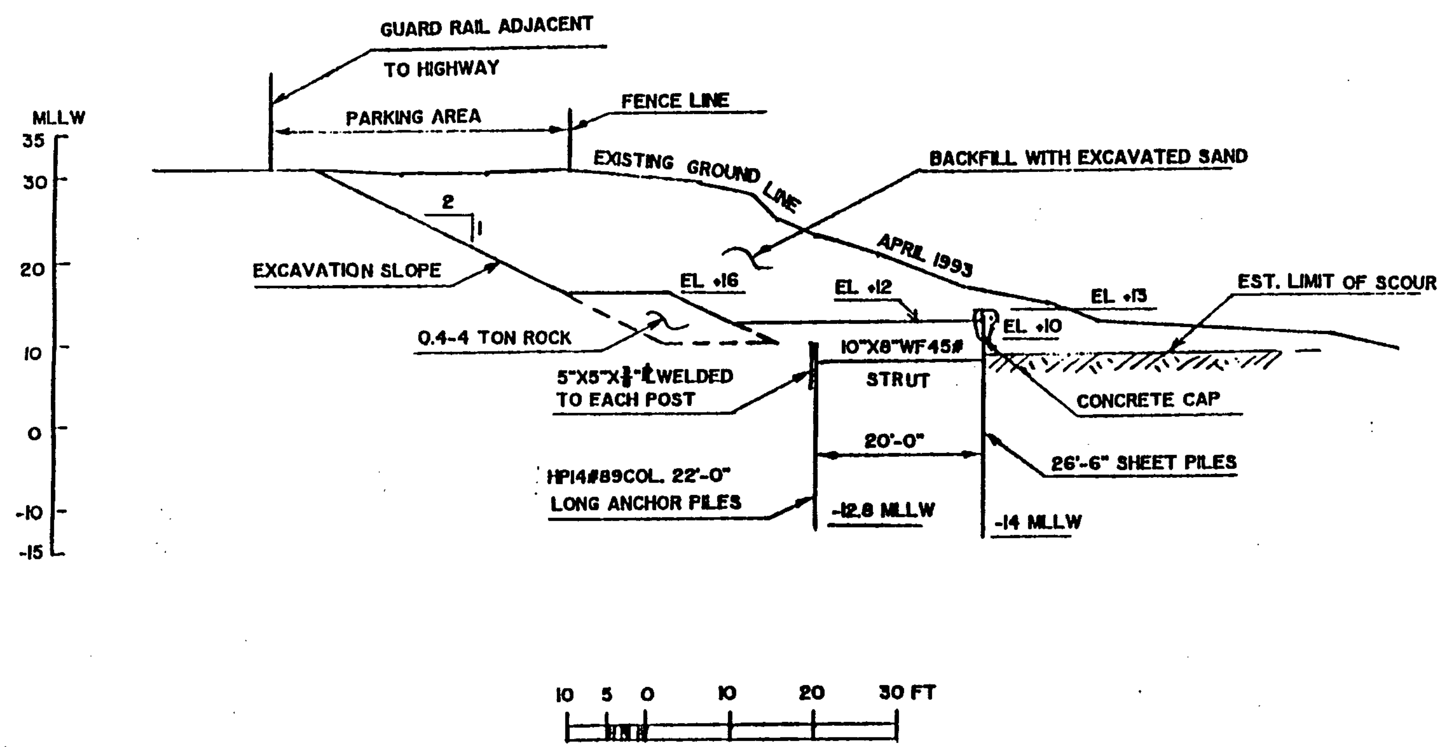
PLATE 42



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

NORTHERN PARKING LOT
TARAVAL—TYPE WALL CROSS SECT.

PLATE 43

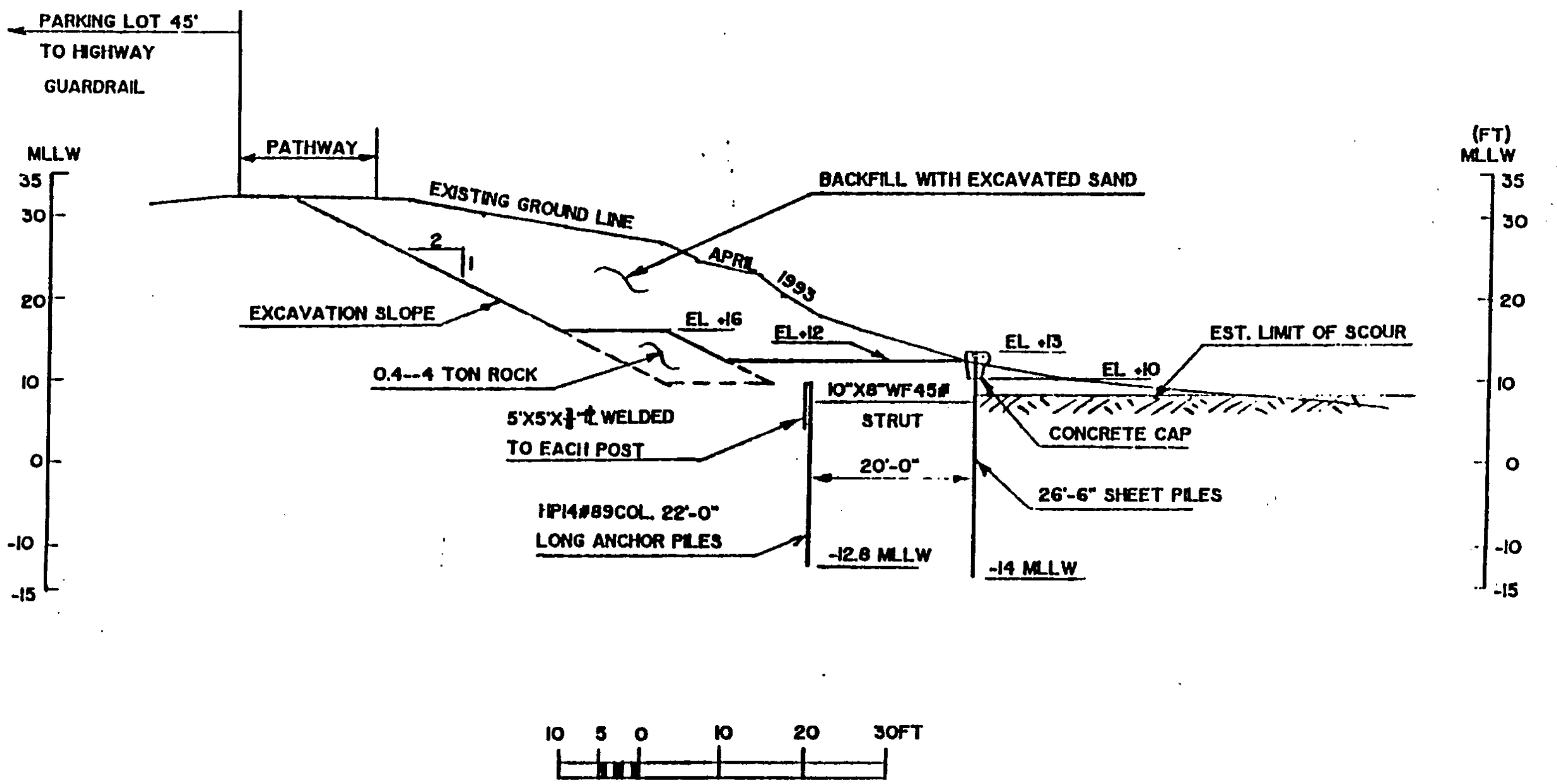


OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

MIDDLE PARKING LOT

TARAVAL–TYPE WALL CROSS SECT.

PLATE 44



OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY

SOUTHERN PARKING LOT
TARAVAL-TYPE WALL CROSS SECT.

PLATE 45

D

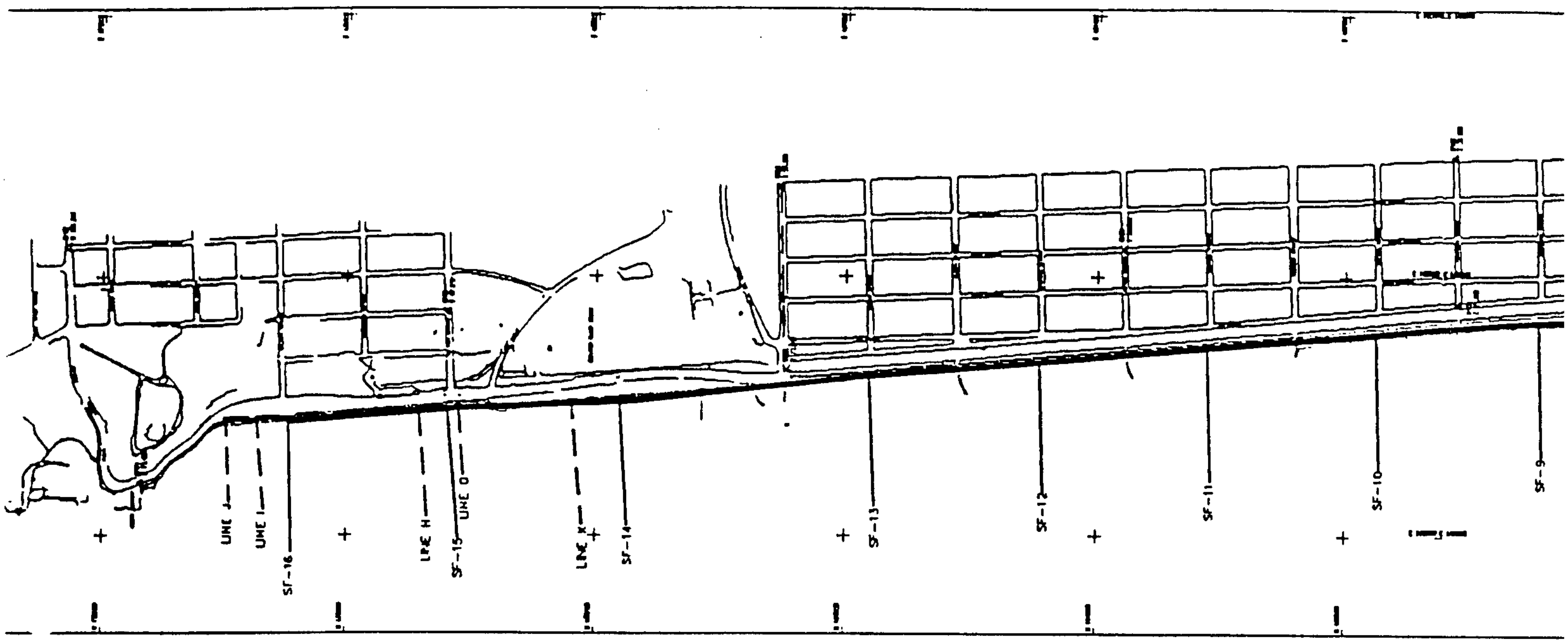
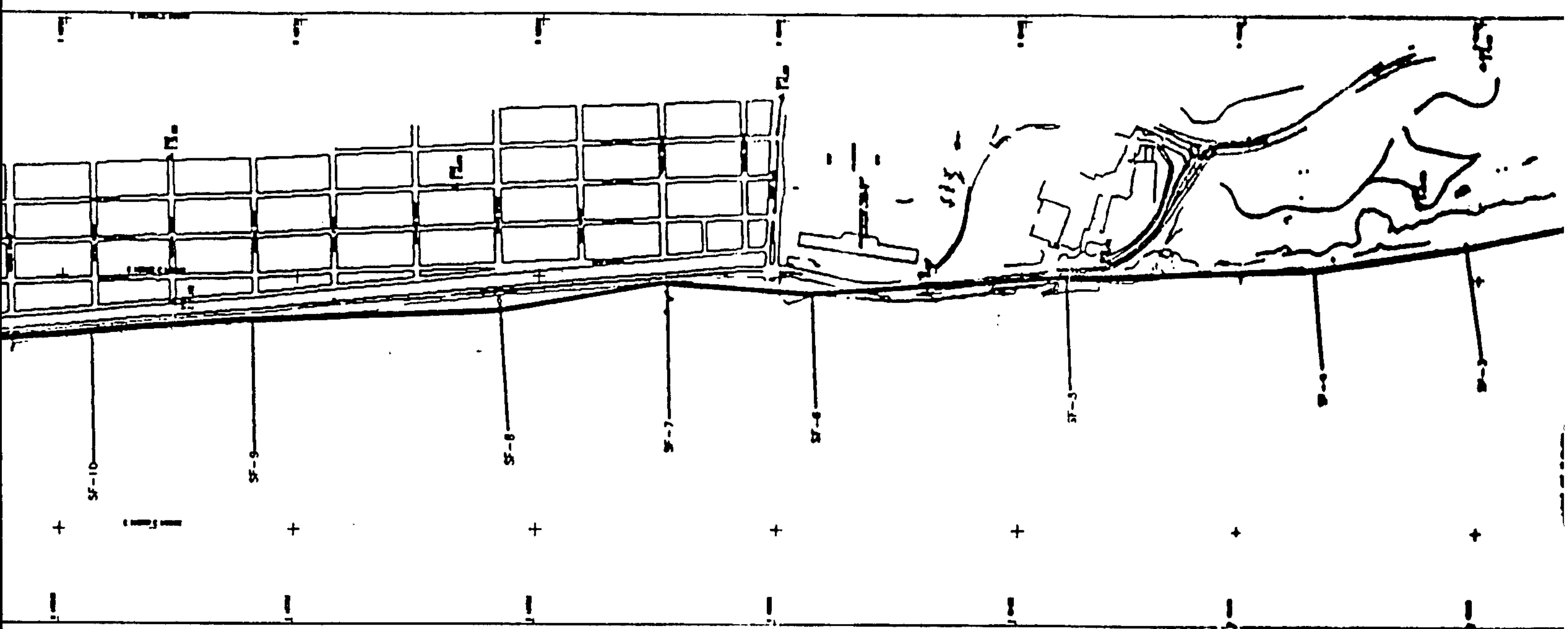


PLATE 46 Horizontal Datums and Profile Locations
for 1959, 1970, 1992, 1993 Data Sets

2

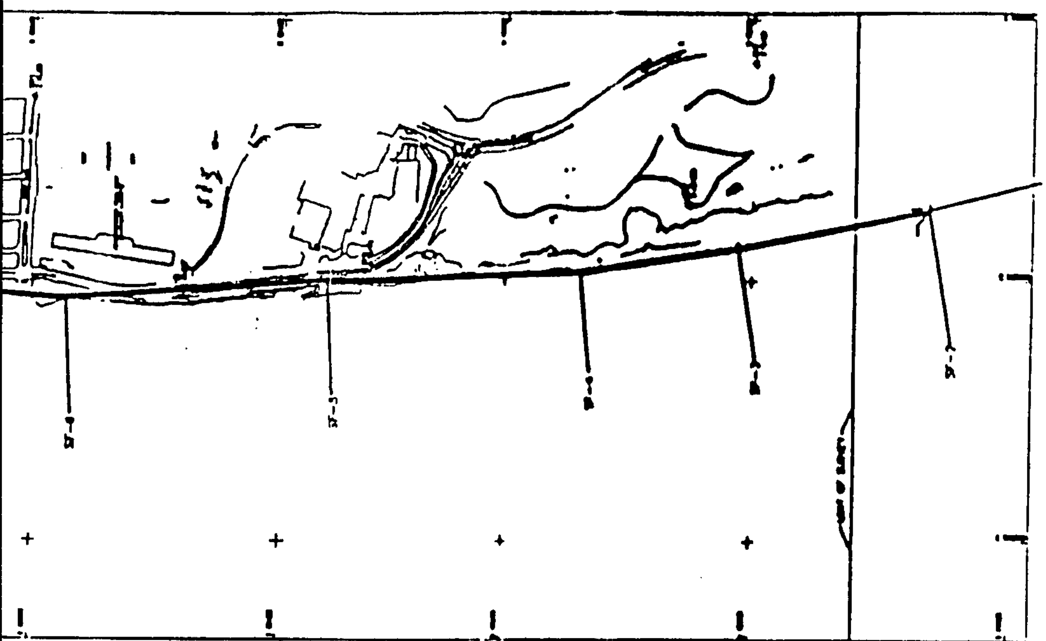


USACE established baseline and Profile Locations

(1959 toe of slope, 1970, 1992, 1993 Data Sets)

Baseline and Profile Locations for 1959 wetted bound

3



and Profile Locations

992, 1993 Data Sets)

rs for 1959 wetted bound

1

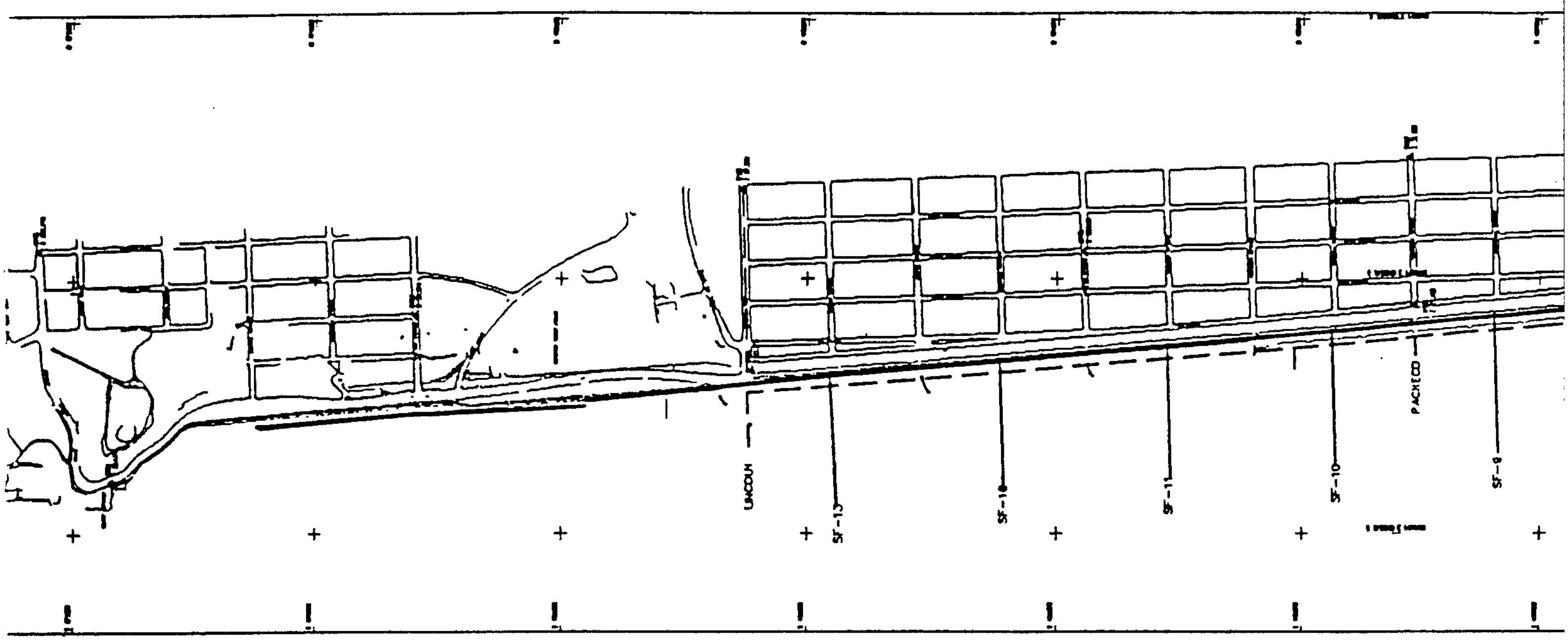
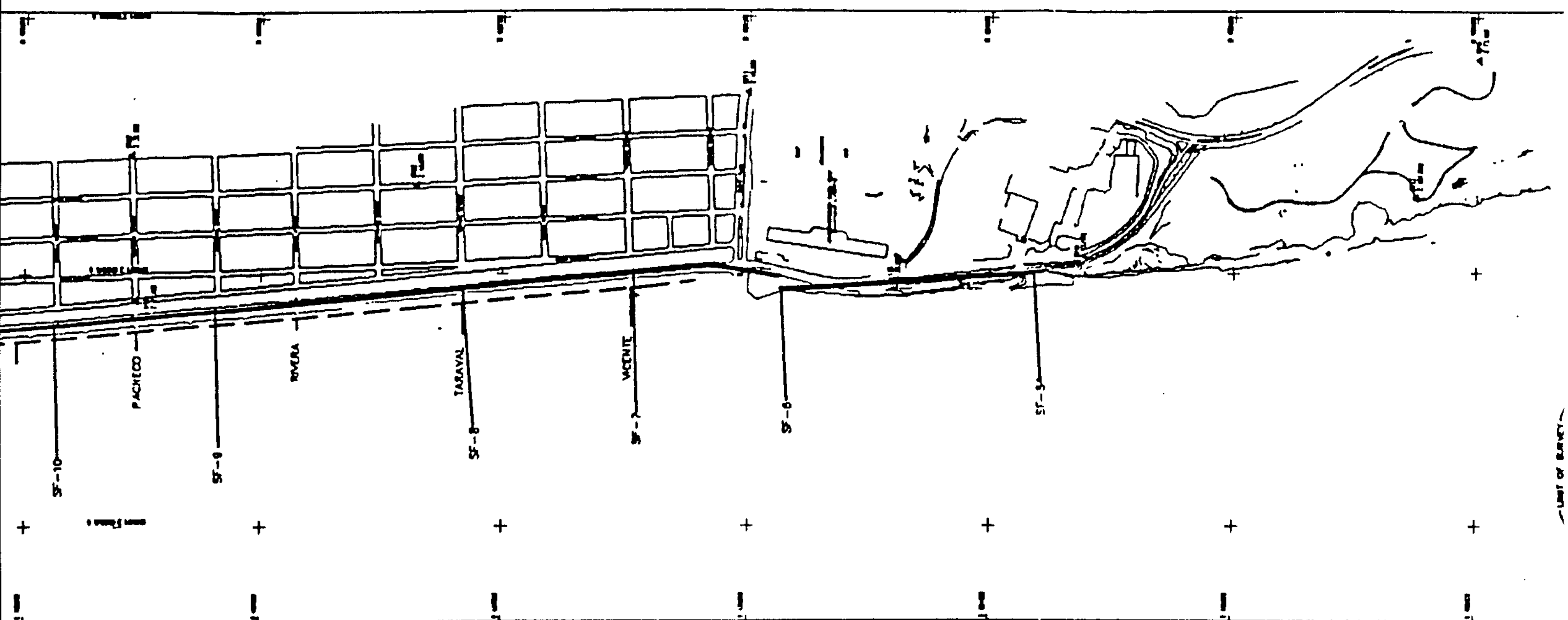


PLATE 47. Horizontal Datums and Profile Locations
for 1979, 1980, 1985, 1986 Data Sets

2

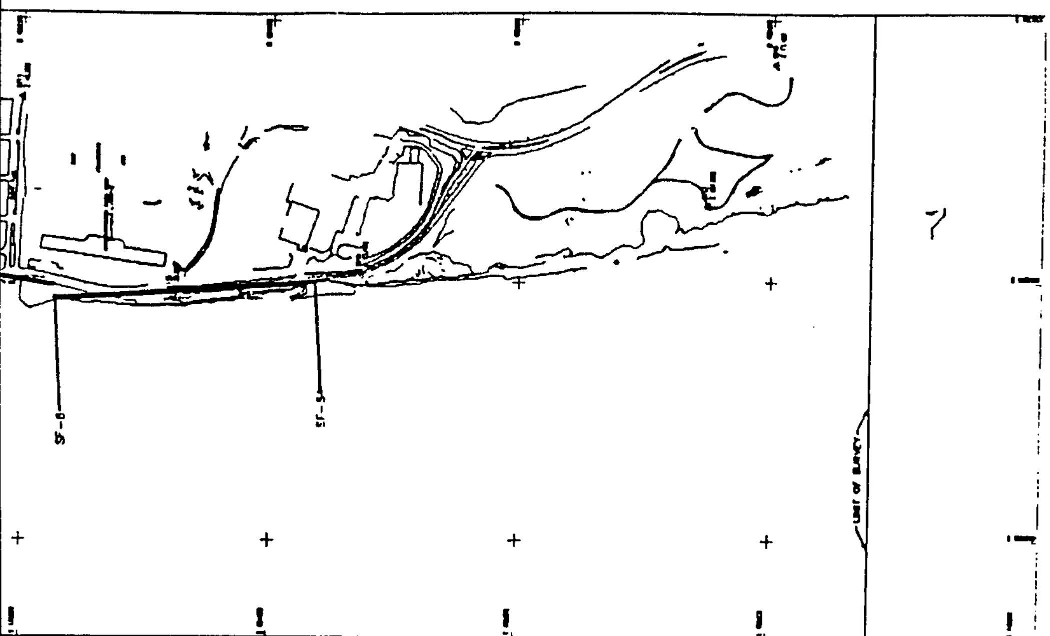


City established baseline for 1979 data set;
Profile locations coincide with USACE established profiles.

Approximate GGNRA Boundary (coincides with pre-1987 West Edge of Upper Great Highway); Profile locations along approximate centerline of streets shown.

(1980, 1985, 1986 data sets)

3



1979 data set;

USACE established profiles.

y (coincides with pre-1987

ghway); Profile locations along

eets shown.

sets)

Attachment A

TABLE A1

DEFINITION OF WAVE STATISTIC ABBREVIATIONS	
Abbreviation	Definition
HT	Significant wave height in meters.
T	Peak wave period in seconds.
DIR	Direction in degrees.
rms	Root mean square of the difference between the hindcast data and the buoy data.
dif	Individual buoy readings minus the hindcast data, summed and averaged.
Num of comp	Number of comparisons made.
Avg Hind HT	Average of the hindcast wave heights, in meters, for the month shown.
Max Hind HT	Maximum wave height, in meters, of the hindcast waves for the month shown.
Avg Hind T	Average of the hindcast wave periods, in seconds, for the month shown.
Max Hind T	Maximum wave period, in seconds, of the hindcast waves for the month shown.

TABLE 2. Wave Statistics For 1982

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Buoy Compared To 46013												
=====												
rms HT						0.6	0.6	0.8	0.6	0.5	0.6	0.7
dif HT						-0.3	0.0	-0.3	-0.1	-0.3	-0.1	-0.4
rms T						7.0	6.0	7.1	4.2	4.3	3.2	3.3
dif T						-5.8	-4.7	-6.0	-2.6	-2.9	-1.4	-1.9
Num of comp						717.0	741.0	740.0	718.0	743.0	720.0	736.0
Avg Hind HT						1.6	1.8	1.6	1.7	1.9	2.1	3.0
Max Hind HT						3.2	3.1	3.2	3.3	3.4	5.8	5.8
Avg Hind T						13.9	13.2	13.3	12.1	13.5	12.6	14.3
Max Hind T						22.0	22.0	22.0	19.0	20.0	20.0	20.0
Buoy Compared To 46026												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT						1.3	1.5	1.4	1.4	1.5	1.6	2.3
Max Hind HT						2.2	2.5	2.9	2.5	2.3	4.8	4.8
Avg Hind T						14.9	14.6	13.8	12.1	14.0	12.0	14.7
Max Hind T						22.0	20.0	22.0	20.0	24.0	20.0	20.0
Buoy Compared To 46042												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT						1.8	2.1	1.9	2.1	2.1	2.3	3.2
Max Hind HT						3.1	3.6	3.6	3.4	3.9	6.0	6.3
Avg Hind T						13.4	12.7	13.2	12.5	13.5	13.0	14.5
Max Hind T						22.0	20.0	22.0	20.0	20.0	20.0	22.0
Buoy Compared To Farallon Islands												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT						1.8	2.1	1.8	2.0	2.1	2.2	3.2
Max Hind HT						3.1	3.5	3.5	3.4	3.8	6.3	6.3
Avg Hind T						13.3	12.7	13.1	12.2	13.5	12.8	14.4
Max Hind T						22.0	20.0	22.0	19.0	20.0	20.0	20.0

TABLE 3. Wave Statistics For 1983

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Buoy Compared To 46013												
=====												
rms HT	1.1	1.1	0.5	0.6	0.7	0.8	0.9	0.5	0.9	0.5	1.0	1.0
dif HT	-0.4	-0.6	0.0	0.0	0.2	0.2	0.3	0.1	0.6	-0.2	-0.2	0.0
rms T	2.8	2.7	1.6	4.5	5.7	5.3	4.6	6.5	4.7	5.4	2.8	3.9
dif T	-0.8	0.2	-1.4	-2.9	-4.4	-3.9	-3.5	-5.4	-4.1	-3.2	-0.5	-1.8
Num of comp	737.0	356.0	49.0	683.0	740.0	708.0	741.0	740.0	715.0	732.0	713.0	632.0
Avg Hind HT	3.3	3.9	3.9	2.2	1.8	2.2	1.9	1.6	1.2	2.0	3.5	2.9
Max Hind HT	7.6	6.6	6.2	5.0	4.3	4.9	3.1	2.7	2.3	3.8	9.7	8.7
Avg Hind T	13.9	14.3	14.2	13.0	12.7	12.4	11.5	13.2	13.2	13.4	12.7	12.8
Max Hind T	24.0	19.0	20.0	19.0	18.0	18.0	16.0	19.0	17.0	22.0	20.0	20.0
Buoy Compared To 46026												
=====												
rms HT	0.8	0.7	0.8	0.5	0.5	0.5	0.5	0.4	0.4	0.6	0.8	0.4
dif HT	-0.2	-0.1	-0.5	-0.1	-0.1	0.0	0.0	-0.2	0.2	-0.4	-0.3	-0.1
rms T	2.8	2.9	3.6	5.7	6.2	5.7	4.7	6.7	5.4	5.5	2.9	3.4
dif T	-0.5	-0.1	-1.6	-4.3	-5.0	-4.4	-3.6	-5.9	-4.9	-3.4	-0.5	-2.6
Num of comp	716.0	643.0	708.0	707.0	739.0	711.0	740.0	723.0	713.0	740.0	704	59
Avg Hind HT	2.7	3.2	3.3	1.7	1.4	1.7	1.5	1.3	1.0	1.6	2.7	2.4
Max Hind HT	6.5	5.5	5.8	3.7	3.3	3.5	2.4	2.2	1.9	3.5	7.9	7.8
Avg Hind T	13.7	14.0	14.1	13.6	13.2	12.9	11.8	13.8	14.0	13.3	12.4	12.8
Max Hind T	24.0	20.0	20.0	19.0	18.0	18.0	16.0	20.0	18.0	22.0	20.0	20.0
Buoy Compared To 46042												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT	3.4	4.0	4.1	2.5	2.2	2.8	2.4	2.0	1.6	2.4	3.5	3.0
Max Hind HT	7.2	6.7	7.3	5.7	6.0	6.3	4.3	13.0	3.0	5.4	7.9	8.8
Avg Hind T	14.1	14.8	14.5	13.3	12.0	12.1	11.2	3.8	13.6	13.6	13.3	13.2
Max Hind T	22.0	19.0	20.0	18.0	18.0	18.0	15.0	20.0	20.0	22.0	20.0	20.0
Buoy Compared To Farallon Islands												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT	3.4	4.0	4.0	2.4	2.1	2.6	2.2	1.9	1.6	2.3	3.6	3.0
Max Hind HT	7.5	6.7	6.9	5.4	5.6	5.9	3.7	3.4	3.2	4.5	9.1	8.7
Avg Hind T	14.0	14.6	14.3	13.1	12.1	12.3	11.3	12.8	13.3	13.4	12.9	13.0
Max Hind T	24.0	19.0	20.0	18.0	17.0	18.0	16.0	19.0	17.0	22.0	20.0	20.0

TABLE 4. Wave Statistics For 1984

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Buoy Compared To 46013												
=====												
rms HT		0.7	0.7	1.0	0.8							
dif HT		-0.1	0.0	0.1	0.1							
rms T		2.0	3.2	3.4	4.0							
dif T		-0.5	-1.4	-2.0	-2.6							
Num of comp		689.0	737.0	714.0	731.0							
Avg Hind HT		2.8	2.9	2.9	2.2							
Max Hind HT		4.7	4.7	5.4	5.4							
Avg Hind T		13.7	13.6	13.4	11.9							
Max Hind T		18.0	19.0	2.0	17.0							
Buoy Compared To 46026												
=====												
rms HT		0.6	0.6	0.6	0.5							
dif HT		-0.2	-0.2	-0.1	0.0							
rms T		2.2	3.8	3.7	4.4							
dif T		-0.7	-2.1	-2.0	-2.2							
Num of comp		683.0	727.0	708.0	726.0							
Avg Hind HT		2.1	2.3	2.2	1.8							
Max Hind HT		3.5	3.9	3.6	3.9							
Avg Hind T		13.5	14.0	13.0	12.2							
Max Hind T		18.0	20.0	20.0	18.0							
Buoy Compared To 46042												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT	2.3	3.0	3.2	3.6	2.8							
Max Hind HT	5.5	5.2	5.1	6.0	6.8							
Avg Hind T	14.0	13.9	14.0	13.1	11.3							
Max Hind T	20.0	19.0	20.0	20.0	17.0							
Buoy Compared To Farallon Islands												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT	2.2	2.9	3.1	3.3	2.6							
Max Hind HT	5.3	4.9	4.9	5.6	11.7							
Avg Hind T	13.9	13.7	13.8	12.9	6.5							
Max Hind T	19.0	18.0	20.0	19.0	17.0							

TABLE 5. Wave Statistics For 1987

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Buoy Compared To 46013												
=====												
rms HT						0.5	0.6	0.4	0.5	0.4	0.5	
dif HT						0.3	0.2	0.1	0.1	-0.1	0.2	
rms T						4.7	4.4	5.1	6.1	3.9	2.3	
dif T						-2.8	-3.0	-2.9	-4.2	-1.7	-0.3	
Num of comp						715.0	738.0	740.0	678.0	741.0	360.0	
Avg Hind HT						1.8	1.6	1.5	1.8	1.6	2.4	3.1
Max Hind HT						3.5	3.7	2.0	4.0	2.4	3.7	6.9
Avg Hind T						13.1	12.1	14.0	14.7	14.0	13.2	13.8
Max Hind T						19.0	17.0	18.0	24.0	22.0	19.0	22.0
Buoy Compared To 46026												
=====												
rms HT						0.4	0.5					
dif HT						0.2	0.3					
rms T						5.5	4.3					
dif T						-3.7	-2.3					
Num of comp						715.0	301.0					
Avg Hind HT						1.4	1.3	1.3	1.4	1.2	1.8	2.3
Max Hind HT						2.6	2.7	2.0	3.1	1.9	3.0	5.3
Avg Hind T						14.8	12.5	14.2	15.1	14.7	13.4	13.6
Max Hind T						20.0	18.0	18.0	24.0	24.0	20.0	22.0
Buoy Compared To 46042												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT						2.1	2.0	1.8	2.1	1.9	2.7	3.4
Max Hind HT						3.8	3.3	2.3	4.4	2.8	3.9	7.6
Avg Hind T						12.6	11.6	13.6	14.2	13.9	13.5	14.0
Max Hind T						18.0	16.0	17.0	22.0	22.0	20.0	22.0
Buoy Compared To Farallon Islands												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT						2.0	1.9	1.7	2.0	1.8	2.6	3.3
Max Hind HT						3.8	3.7	2.2	4.4	2.5	3.8	7.2
Avg Hind T						12.6	11.8	13.6	14.1	13.9	13.2	13.7
Max Hind T						19.0	16.0	17.0	19.0	22.0	20.0	20.0

TABLE 6. Wave Statistics For 1988

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Buoy Compared To 46013												
=====												
rms HT			0.8	0.7	0.5							
dif HT			0.1	-0.2	0.0							
rms T			2.8	2.0	4.6							
dif T			-1.0	-0.3	-2.8							
Num of comp			389.0	718.0	737.0							
Avg Hind HT	2.5	2.0	2.6	2.3	2.2							
Max Hind HT	4.4	3.9	4.4	4.4	3.8							
Avg Hind T	13.8	13.5	13.9	13.1	13.6							
Max Hind T	20.0	18.0	20.0	18.0	22.0							
Buoy Compared To 46026												
=====												
rms HT	0.7	0.5	0.5	0.5	0.3							
dif HT	0.3	0.3	0.0	-0.1	0.0							
rms T	2.8	2.9	2.7	2.6	5.2							
dif T	0.8	1.3	-0.5	-0.7	-3.4							
Num of comp	467.0	632.0	742.0	709.0	667.0							
Avg Hind HT	2.0	1.5	2.0	1.8	1.7							
Max Hind HT	3.9	2.7	3.3	3.9	2.8							
Avg Hind T	13.5	13.5	13.9	13.5	14.2							
Max Hind T	20.0	18.0	20.0	18.0	22.0							
Buoy Compared To 46042												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT	2.8	2.3	3.0	2.7	2.5							
Max Hind HT	5.3	5.0	4.7	5.0	4.4							
Avg Hind T	14.2	13.6	13.8	13.0	12.8							
Max Hind T	20.0	18.0	20.0	18.0	20.0							
Buoy Compared To Farallon Islands												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT	2.7	2.2	2.9	2.6	2.4							
Max Hind HT	4.6	4.7	4.5	4.9	4.0							
Avg Hind T	13.9	13.6	13.7	13.0	13.1							
Max Hind T	20.0	18.0	19.0	18.0	20.0							

TABLE 7. Wave Statistics For 1991

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Buoy Compared To 46013												
=====												
rms HT						0.7	0.4	0.6	0.7	0.8	0.6	0.7
dif HT						0.0	0.1	-0.2	0.1	-0.1	0.2	0.2
rms T						5.8	5.2	4.1	3.9	3.7	2.6	4.2
dif T						-3.9	-4.1	-2.7	-1.8	-1.5	0.1	-0.7
Num of comp						718.0	741.0	735.0	719.0	742.0	717.0	735.0
Avg Hind HT						2.0	1.5	1.7	1.7	2.0	2.4	2.4
Max Hind HT						3.3	2.6	3.2	3.5	3.8	5.0	4.3
Avg Hind T						13.9	13.0	12.1	13.7	12.7	13.0	14.4
Max Hind T						20.0	20.0	17.0	20.0	20.0	19.0	24.0
Buoy Compared To 46026												
=====												
rms HT						0.6	0.3	0.6	0.6	0.7	0.4	0.5
dif HT						-0.1	-0.1	-0.3	-0.1	-0.3	0.1	0.2
rms T						5.7	5.1	4.0	4.4	3.5	2.6	4.3
dif T						-4.1	-3.6	-2.4	-2.2	-1.2	0.3	-0.6
Num of comp						715.0	739.0	740.0	720.0	742.0	716	733
Avg Hind HT						1.7	1.3	1.4	1.4	1.6	1.8	1.8
Max Hind HT						2.8	2.1	2.6	3.2	3.2	3.8	3.9
Avg Hind T						14.5	14.0	12.5	14.6	12.9	12.9	14.3
Max Hind T						20.0	20.0	17.0	20.0	20.0	19.0	26.0
Buoy Compared To 46042												
=====												
rms HT						0.7	0.4			0.8	0.6	0.7
dif HT						-0.4	-0.3			-0.4	-0.1	0.0
rms T						4.1	3.6			3.2	2.6	3.9
dif T						-2.5	-2.0			-1.5	-0.3	-1.3
Num of comp						715.0	735.0			735.0	708.0	728.0
rms DIR						56.9	63.8			56.8	31.6	29.4
dif DIR						30.7	37.2			37.5	14.1	7.0
Avg Hind HT						2.4	1.8	2.0	2.1	2.4	2.8	2.8
Max Hind HT						3.7	3.0	3.4	4.6	4.2	5.3	5.0
Avg Hind T						12.9	12.0	11.7	13.8	13.0	13.1	14.6
Max Hind T						18.0	20.0	17.0	20.0	20.0	19.0	24.0
Buoy Compared To Farallon Islands												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT						2.3	1.7	1.9	2.0	2.3	2.6	2.7
Max Hind HT						3.9	3.0	3.4	4.2	4.1	5.2	4.9
Avg Hind T						13.1	12.2	11.8	13.5	12.7	13.1	14.4
Max Hind T						19.0	20.0	17.0	20.0	19.0	19.0	24.0

TABLE 8. Wave Statistics For 1992

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Buoy Compared To 46013												
=====												
rms HT	0.7	0.6	0.7			0.3	0.5	0.7	0.9	0.7	0.9	0.9
dif HT	0.1	-0.2	-0.3			0.0	0.3	0.4	0.5	0.5	0.5	0.4
rms T	2.2	2.4	3.9			3.2	3.8	4.9	3.4	2.8	2.9	2.6
dif T	-0.1	-0.5	-1.9			1.3	-1.8	-3.4	-1.4	0.2	0.0	0.1
Num of comp	739.0	688.0	268.0			187.0	724.0	729.0	699.0	711.0	671.0	718.0
Avg Hind HT	2.8	2.8	2.4	2.0	1.3	1.3	1.3	1.2	1.3	1.6	1.8	2.6
Max Hind HT	4.7	4.7	3.8	3.6	2.4	2.2	2.3	1.9	2.1	2.8	3.8	5.3
Avg Hind T	14.2	12.7	13.9	11.8	11.9	10.9	11.3	12.1	11.5	11.6	12.2	12.6
Max Hind T	20.0	18.0	20.0	19.0	17.0	14.0	16.0	17.0	18.0	14.0	17.0	16.0
Buoy Compared To 46026												
=====												
rms HT	1.5	0.5	0.5	0.5	0.5	0.4	0.3			0.4	0.6	0.6
dif HT	-1.5	-0.2	0.0	0.0	0.3	0.2	0.0			0.2	0.3	0.1
rms T	7.3	2.5	3.6	4.1	3.8	3.1	3.2			3.4	3.4	3.0
dif T	-7.3	0.0	-0.4	-1.0	-0.8	-0.8	0.3			1.1	0.5	0.7
Num of comp	1.0	680.0	728.0	715.0	708.0	699.0	488.0			686.0	698	722
Avg Hind HT	2.2	2.4	1.9	1.7	1.1	1.0	1.1	1.5	1.1	1.3	1.3	1.9
Max Hind HT	4.0	4.5	3.2	2.8	2.1	1.8	1.8	1.5	1.8	2.2	3.1	4.6
Avg Hind T	13.9	12.1	13.7	12.5	11.5	10.9	11.5	13.1	11.5	11.2	11.8	11.9
Max Hind T	20.0	18.0	20.0	20.0	17.0	14.0	16.0	17.0	17.0	14.0	18.0	17.0
Buoy Compared To 46042												
=====												
rms HT		0.7	0.7	1	0.6	0.6	0.5					1
dif HT		-0.5	-0.4	-0	0.3	0.3	0.0					0
rms T		2.8	2.9	3.2	3.3	2.7	3.3					2.5
dif T		-1.0	-0.7	-0.6	-0.8	-0.7	-0.6					-0.6
Num of comp		686.0	730.0	716.0	740.0	714.0	733.0					671.0
rms DIR		38.4	28.1	32.4	52.8	52.7	64.0					24.7
dif DIR		-8.2	-1.2	12.2	31.0	26.2	26.7					8.8
Avg Hind HT	3.0	3.0	2.7	2.2	1.6	1.5	1.6	1.4	1.5	1.8	2.0	2.8
Max Hind HT	4.6	4.9	4.2	4.3	3.2	2.8	2.7	2.2	2.9	2.9	3.7	5.6
Avg Hind T	14.5	13.2	14.0	11.9	11.4	10.5	10.5	11.5	11.2	11.6	12.5	13.0
Max Hind T	19.0	19.0	20.0	17.0	16.0	14.0	15.0	17.0	17.0	14.0	18.0	18.0
Buoy Compared To Farallon Islands												
=====												
rms HT												
dif HT												
rms T												
dif T												
Num of comp												
Avg Hind HT	3.0	3.0	2.6	2.2	1.5	1.5	1.5	1.3	1.5	1.8	2.0	2.8
Max Hind HT	4.7	5.0	4.0	3.9	3.1	2.5	2.5	2.1	2.6	2.9	3.8	5.7
Avg Hind T	14.2	12.8	13.9	11.8	11.6	10.5	10.8	11.7	11.2	11.6	12.3	12.8
Max Hind T	19.0	18.0	20.0	18.0	16.0	14.0	15.0	17.0	17.0	14.0	18.0	18.0

Attachment B
(From Sand, 1995)

Summary of Dune Line Rates
Average Rate of (1)Erosion/(+)Accretion per year
(significant rates in bold)

	38-48	48-59	59-70	70-71	71-85	85-92	Long Term 38-92
Error ft/yr.	**4**	**3.6**	**3.6**	**40**	**2.8**	**5.7**	**.74**
Reach 1	**13.77**	0.33	-3.05	8.34	0.46	-0.79	**2.17**
Reach 2	**-5.23**	3.42	-1.75	6.9	-1.71	5.34	-0.25
Reach 3	-3.5	**4.64**	-3.07	4.38	-0.20	3.60	-0.15
Reach 4	-1.82	1.38	-0.4	19.42	-0.87	1.39	0.18
Reach 5	**-4.25**	1.36	-0.84	38.66	-1.51	**6.12**	0.44
Reach 6	**-6.6**	**5.61**	**-4.09**	26.02	**-7.19**	seawall	seawall
Reach 7	-2.62	**6.35**	**-7.21**	35.12	**-7.08**	-0.62	**-1.93**
Reach 8	-2.11	1.54	-2.55	10.84	**-3.03**	3.03	**-0.79**
Reach 9	seawall	seawall	seawall	seawall	seawall	seawall	seawall
All Reaches*	0.25	2.72	-3.00	14.29	-2.57	2.12	0.297

*This average is weighted with respect to length of reach.

Summary of Wetted Bound Rates
Average Rate of Erosion/Accretion per year
(significant rates in bold)

	38-48	48-59	59-70	70-71	71-85	85-92	Long Term 38-92
Error ft/yr.	**6**	**5.4**	**5.4**	**60**	**4.28**	**8.5**	**1.11**
Reach 1	-5.37	2.14	**-7.07**	21.36	1.18	**8.95**	-0.19
Reach 2	4.66	3.81	**-10.54**	5.27	**7.47**	4.76	**2.14**
Reach 3	**15.62**	2.5	**-11.03**	-0.39	3.87	**10.13**	**3.46**
Reach 4	**22.2**	3.44	**-9.97**	20.57	**-5.01**	**20.16**	**4.48**
Reach 5	**27.73**	1.06	**-10.39**	11.17	-4.00	**12**	**3.96**
Reach 6	**15.5**	-1.9	**-15.01**	-3.09	**-5.80**	**20**	0.46
Reach 7	**14.11**	-2.1	**-14.5**	10.25	**-5.12**	**21.25**	0.85
Reach 8	**6.56**	-5.35	**-11.4**	-3.88	**9.67**	5.43	0.94
Reach 9	-4.7	**-11.1**	0.28	-15.7	**9.65**	**22.02**	1.99
All Reaches*	5.02	-2.52	**-8.65**	1.55	3.73	**13.03**	**1.34**

*This average is weighted with respect to length of reach.

1938 -1948 Dune Line/Wetted Bound

During this ten year time period dune line reach 2 experienced up to 6 ft of erosion per year, while reach 1 was experiencing over 13 feet of accretion per year. See Graph below. The erosion may be the result of the winter storms of 1939 and a series of storms during 1943-48. No historical information exists to account for the accretion along reach 1. It could be explained by unrecorded dumping of sand, possible slumping of cliffs or a variable that existed in the beach dynamics during that time.

In this same ten-year time period, wetted bound reaches 2-8 were experiencing accretion while reaches 1 and 9 were experiencing erosion. See Graph below. The erosion may be the result of the winter storms of 1939 and a series of storms during 1943-48. No historical information exists to account for the accretion along reaches 2-8.

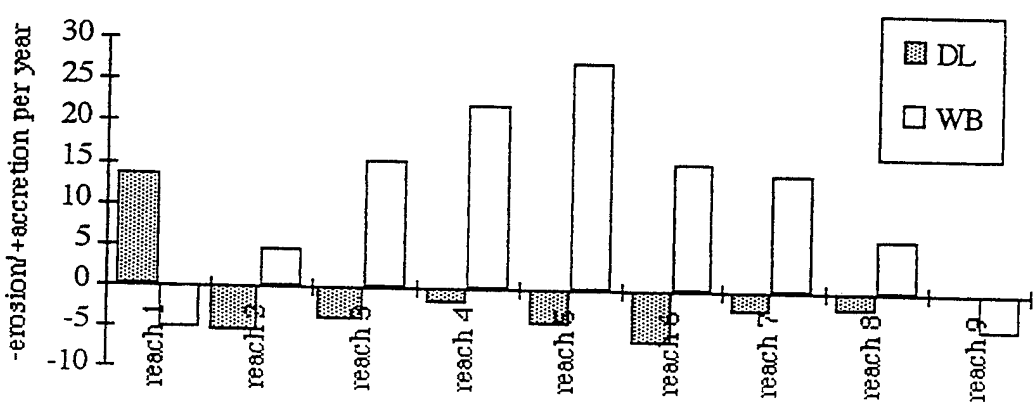
1938-48 Dune Line Error ± 4 feet per year. Significant rates in bold

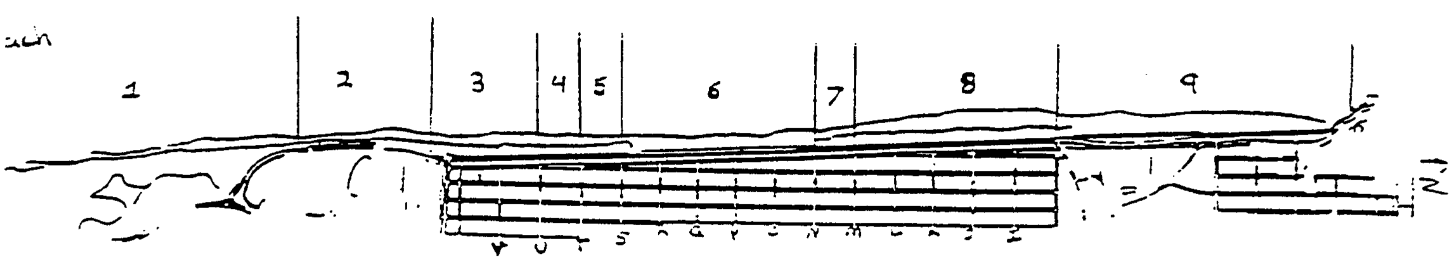
Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	**13.77**	**-5.23**	-3.53	-1.82	**-4.25**	**-6.6**	-2.62	-2.11	SW

1938-48 Wetted Bound Error ± 6 feet per year. Significant rates in bold

Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	-5.37	4.66	**15.62**	**22.2**	**27.73**	**15.5**	**14.11**	**6.56**	-4.7

1938-48 Dune Line/Wetted Bound Comparison





1948-1959 Dune Line/Wetted Bound

During this 11 year period Ocean Beach's dune line was experiencing varying degrees of accretion. See Graph below. Human intervention into the sand at this time consisted of the onset of back dune sand mining. There were two major storms that hit the area at this time in October 1950 and in February of 1953.

During this same 11 year period the wetted bound on Ocean Beach was experiencing varying degrees of accretion and erosion. See Graph below. The southern half of the beach, reach 1-5 was accreting while the northern half, reach 6-9, was eroding. Human intervention into the sand at this time consisted of the onset of sand mining and even though the exact location of sand mining was not recorded it may have been the reason for the erosion on the northern section of the beach. There were two major storms that hit the area at this time in October 1950 and in February of 1953 this may have also attributed to the erosion.

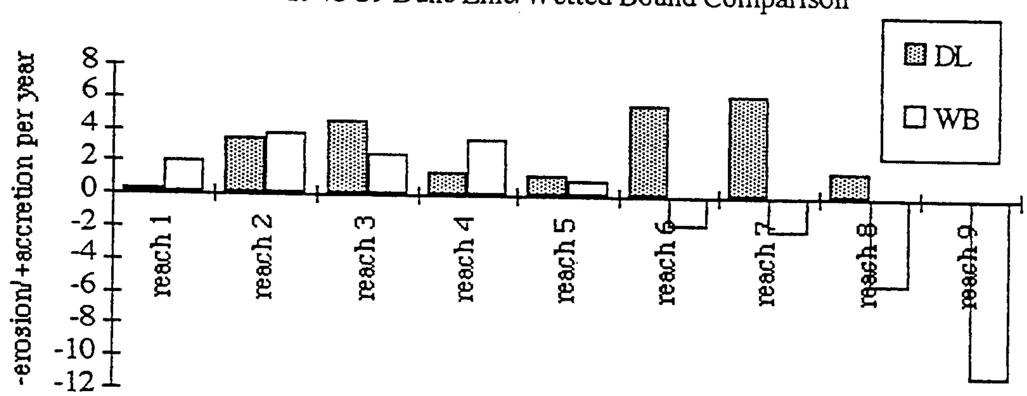
1948-59 Dune Line Error ±3.6 feet per year. Significant rates in bold

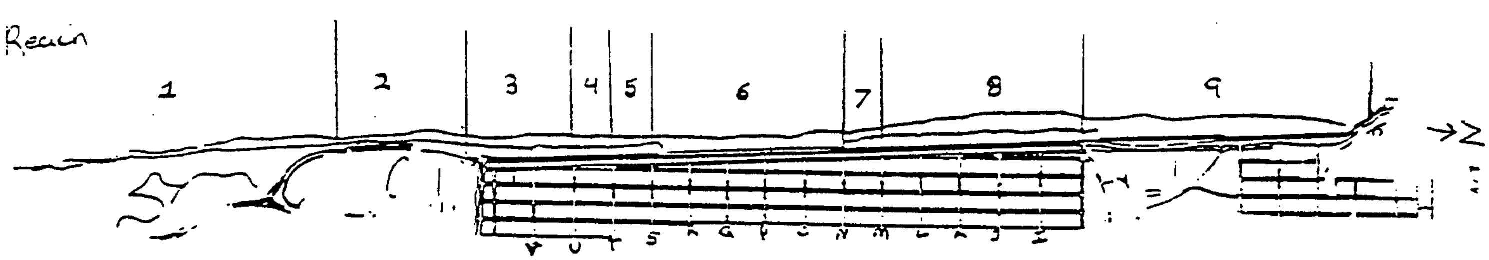
Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	0.33	3.42	**4.64**	1.38	1.36	**5.61**	**6.35**	1.54	SW

1948-59 Wetted Bound Error ±5.4 feet per year. Significant rates in bold

Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	2.14	3.81	2.5	3.44	1.06	-1.9	-2.1	-5.35	-11.1

1948-59 Dune Line/Wetted Bound Comparison





1959-1970 Dune Line/Wetted Bound

During this 11 year period Ocean Beach's dune line was experiencing varying degrees of erosion overall. See Graph below. From 1953-1963 an unknown quantity of sand was mined from the beach in the area between Lincoln Way and Sloat. Also from 1963-1967 100,000 cubic yards of sand were mined from the same area. Sand mining ceased in 1967. The sand mining may account for the erosion rates along the dune line. There were no significant storms during this time period[G].

During this same 11 year period the wetted bound on Ocean Beach was experiencing varying degrees of erosion on reaches 1-8 and accretion on reach 9. See Graph below From 1953-1963 an unknown quantity of sand was mined from the beach in the area between Lincoln Way and Sloat. Also from 1963-1967 100,000 cubic yards of sand were mined from the same area. Sand mining ceased in 1967. The sand mining may account for the erosion rates along the wetted bound. There were no significant storms during this time period.

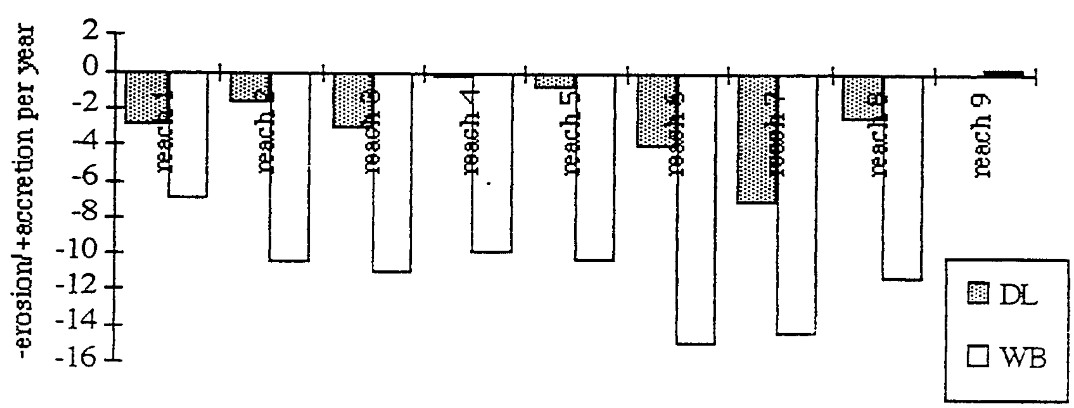
1959-70 Dune Line Error ±3.6 feet per year. Significant rates in bold

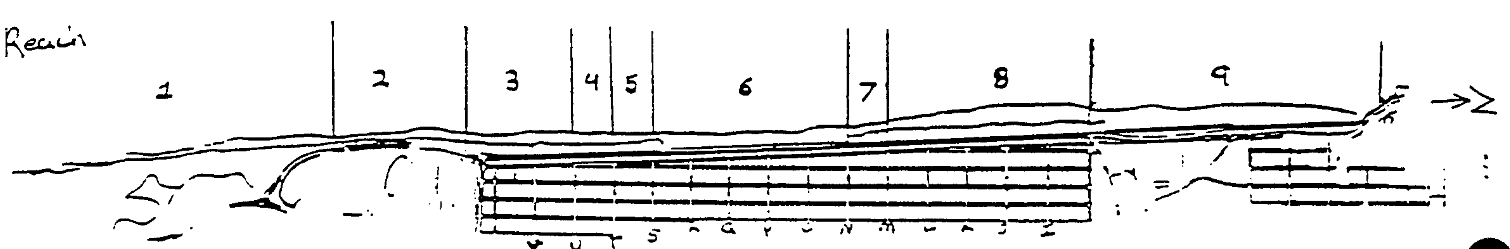
Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	-3.05	-1.75	-3.07	-0.4	-0.84	**-4.09**	**-7.21**	-2.55	SW

1959-70 Wetted Bound Error ±5.4 feet per year. Significant rates in bold

Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	**-7.07**	**-10.5**	**-11.0**	**-9.97**	**10.39**	**-15.0**	**-14.5**	**-11.4**	0.28

1959-70 Dune Line/Wetted Bound Comparison





1970-1971 Dune Line/Wetted Bound

During this one year period all of Ocean Beach's dune line was experiencing an extensive amount of accretion in this time span. See Graph below. There was no evidence found for this time for sand dumping along the dune line and there were no significant storms reported during this year. Since this time period consists of only one year the amount of accretion may be within normal seasonal accretion rates. Also sand mining was terminated on the beach in 1967. This termination may have added to the natural accretion.

During this same one year period the wetted bound on Ocean Beach was experiencing varying amount of accretion and erosion. See Graph Below. There was no evidence found for this time for sand dumping along the wetted bound and there were no significant storms reported during this year. Since this time period consists of only one year the amount of accretion may be within normal seasonal accretion rates. Also sand mining was terminated on the beach in 1967. This termination may have added to the natural accretion.

The aerial photos for 1970 and 1971 were reported [MN] to be of poor quality thus making it "difficult to locate the toe of slope, south of Lincoln Way to Sloat street. The toe of slope line was approximated by connecting vegetation limits, and by using changes in color where elevations changed." This discrepancy in the aerial photos may also affect the erosion/accretion rates for this time period.

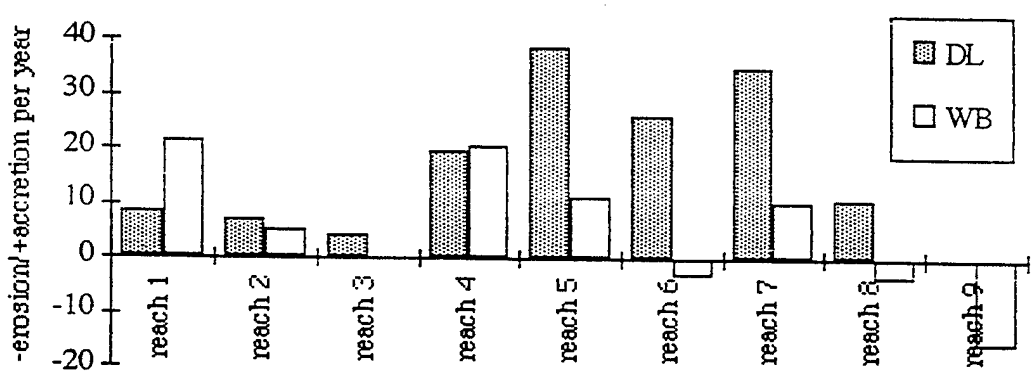
1970-71 Dune Line Error ±40 feet per year. Significant rates in bold

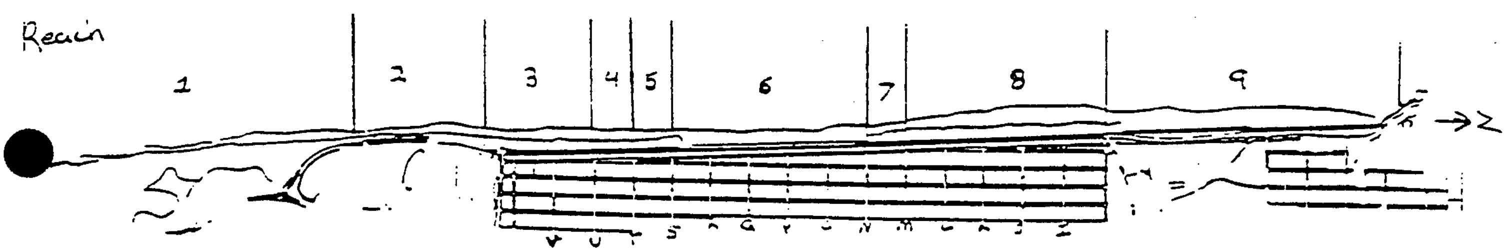
Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	8.34	6.9	4.38	19.42	38.66	26.02	35.12	10.84	SW

1970-71 Wetted Bound Error ±60 feet per year. Significant rates in bold

Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	21.36	5.27	-0.39	20.57	11.17	-3.09	10.25	-3.88	-15.7

1970-71 Dune Line/Wetted Bound Comparison





1971-1985 Dune Line/Wetted Bound

During this 14 year period all of the dune line on Ocean Beach was experiencing varying degrees of erosion. See Graph below. In the early 1970's, fill was placed south of Sloat Blvd. for the Great Highway extenstion. In 1975 Ocean Beach was placed into the care of the GGNRA. This change brought improved sand management to the beach. In 1976 wind blown sand from the Great Highway and the O'Shaughnessy Seawall was placed back on the beach. These practices probably did increase accretion on the dune line, but this effect may have been diminished by a severe winter storm in 1978. This storm may explain the erosion along the dune line. In 1980-81 600,000 cubic yards of sand were placed on the beach from Lincoln Way to Sloat Blvd., extending the dune seaward. For more information see Appendix A. The sand was excavated from beneath the Great Highway for the construction of the Westside Transport Box; 70% of this sand was subsequently eroded during the 1982-1983 winter storms. The variability in erosion and accretion seems to be a natural process along the beach and may be attributed to variables in wave energy and direction as the waves move over the bar.

During this same 14 year time period the wetted bound on Ocean Beach was experiencing accretion on both ends of the beach, reaches 1, 2, 3, 8 and 9. The middle reaches 4, 5, 6 and 7 were experiencing erosion. See Graph below. In 1972, at the southern end of Ocean Beach, rubble was placed and Ice Plant and dune grasses were planted on the dunes; both of these actions may have attributed to the accretion rates at the southern end. In 1976 the GGNRA adopted the practice of returning the wind blown sand to the beach; this may have also attributed to the accretion rates. There was a large storm in the winter of 1978 that may have attributed to the erosion on the central reaches of the beach. In 1980-81 600,000 cubic yards of sand were placed on the beach, extending the wetted bound seaward and adding sand to the littoral system. The sand was excavated from the center of the Great Highway for the construction of the Westside Transport Box. The sand was placed in front of the original dune from Lincoln Way to Sloat Blvd., extending the dune seaward. For additional information see Appendix A. As the dune eroded, sand was added to the littoral system extending the wetted bound seaward. This addition of sand may be reflected as accretion rates in reaches 1, 2, 3, 8 and 9. In the winter of 1982-83, severe storms removed up to 70% of the sand that was placed on the beach in 1980-81. This may account for the erosion on reaches 4, 5, 6 and 7.

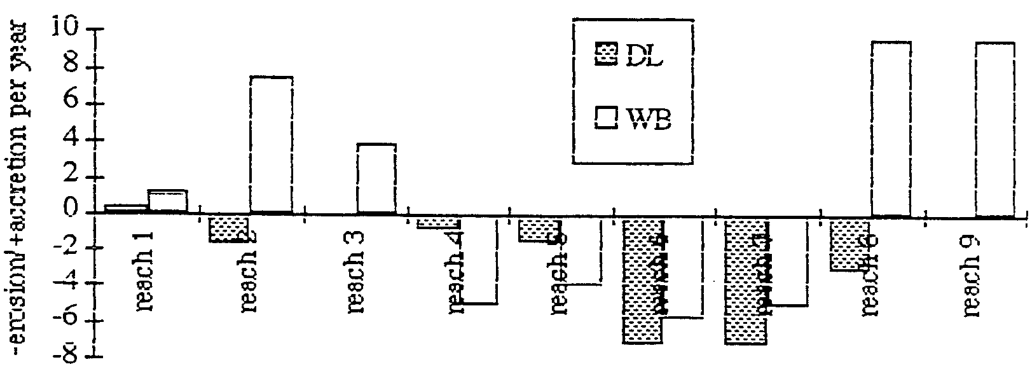
1971-85 Dune Line Error ±2.8 feet per year. Significant rates in bold

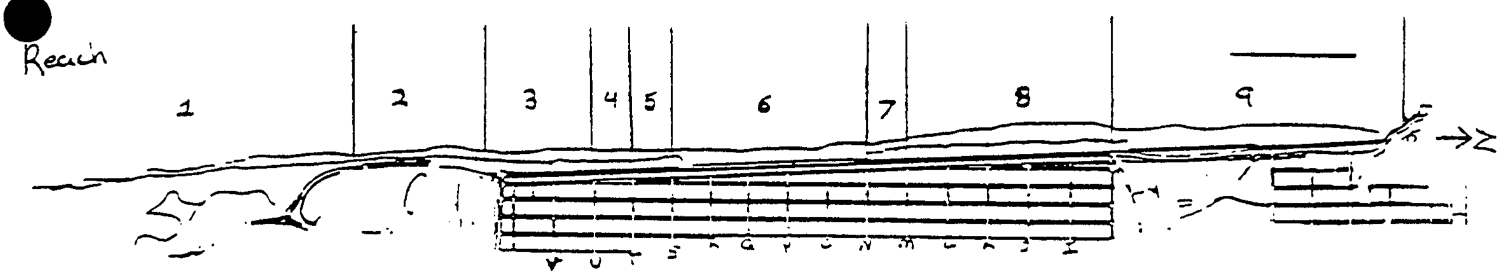
Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	0.46	-1.71	-0.20	-0.87	-1.51	**-7.19**	**-7.08**	**-3.03**	SW

1970-85 Wetted Bound Error ±4.28 feet per year. Significant rates in bold

Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	1.18	**7.47**	3.87	**-5.01**	-4.00	**-5.80**	**-5.12**	**9.67**	**9.65**

1971-85 Dune Line /Wetted Bound Comparison





1985-1992 Dune Line

During this seven year period the dune line along Ocean Beach was experiencing both erosion and accretion. See Graph below. In 1986-88 140,000 cubic yards of sand was placed on the beach. The sand was excavated for the Great Highway Seawall Project. Better sand management practices and the lack of significant storms may have also contributed to dune accretion during this period.

During this same seven year period the wetted bound on Ocean Beach was experiencing accretion along all reaches. See Graph below. In 1986-88 140,000 cubic yards of sand was placed on the beach after the excavation for the new Great Highway Seawall. Also there were no significant storms during this period. These facts combined with GGNRA's practices of moving sand from areas of accretion to areas of erosion may have attributed to the overall accretion seen on the beach during this time.

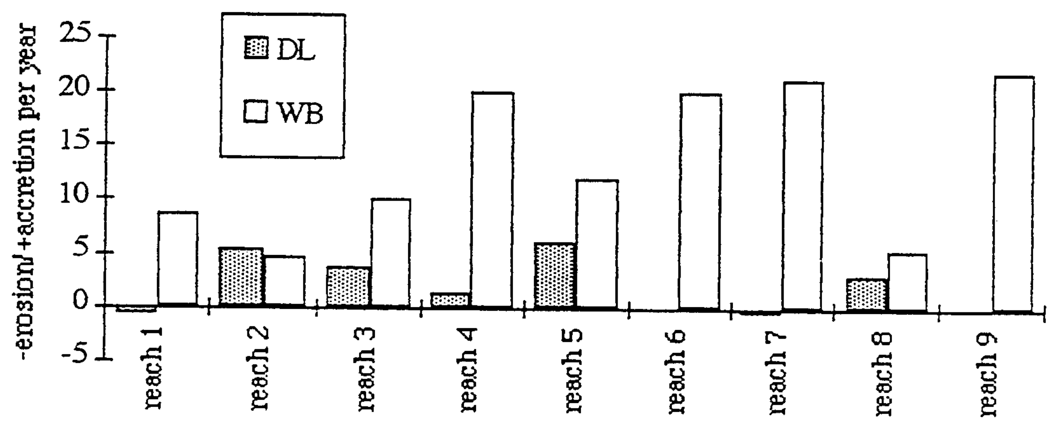
1985-92 Dune Line Error ±5.7 feet per year. Significant rates in bold

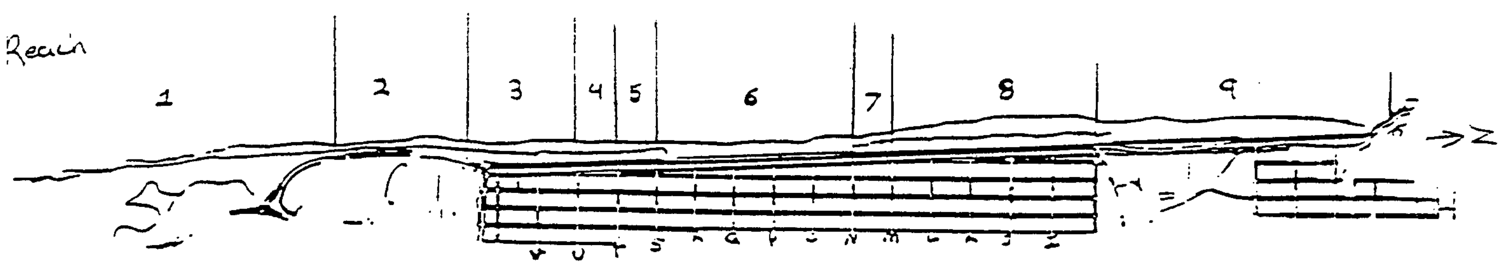
Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	-0.79	5.34	3.60	1.39	**6.12**	SW	-0.62	3.03	SW

1985-92 Wetted Bound Error ±8.5 feet per year. Significant rates in bold

Reach	1	2	3	4	5	6	7	8	9
-Erosion/+accretion ft/year	**8.95**	4.76	**10.13**	**20.16**	12	**20**	**21.25**	5.43	**22.02**

1985-92 Dune Line/Wetted Bound Comparison





11. Conclusions

From the relationships that have been made in this study, one conclusion that can be drawn is that human intervention into the sediment budget can be very effective in the short term but may not appear on the graphical analysis because of the length of time between the aerial photograph years.

An example of this is the 600,000 cubic yards of sand that was placed on the beach in the form of dune nourishment in 1980-81 and its relationship with the El Niño storms of 1982-83. Additional aerial photographs were examined for the dune line, 1978-85, and for the wetted bound, 1980-85. Neither photograph line shows the 600,000 cubic yards of sand placement, but then it would not be expected to, due to the severe storms that hit the area one year after the sand placement.

Additionally, neither of the lines shows the massive amounts of erosion that would be expected to appear after such a storm. The second photograph year for both lines is 1985, so two years had past since the storm and three years since the placement of sand. During the summers of 1983-85 large amounts of sand may have naturally returned to the beach, via the littoral system, or the placement of the 1980-81 dune sand may have buffered the impact of the storm.

During the dune line years of 1971-78 and the wetted bound years of 1971-80, all the dune line reaches and the majority of the wetted bound reaches show erosion. This seems to contradict the human intervention into the area such as the termination of sand mining in 1967, the placement of fill and rubble and the planting of ice plant and grasses in the early 1970's, the ongoing placement of wind blown sand back on the beach, and the transfer of Ocean Beach to the care of the GGNRA. All of these aspects should have and probably did add sand to the beach, but this addition did not appear as accretion on the graphs. Of course, the area may have been in an erosion cycle and the sand addition may have mitigated the erosion somewhat. There was a severe storm during the winter of 1978-79 that may have counteracted any previous accretion that took place during this time period.

The investigation suggests that intermittent human interventions into the sand budget are often not seen in the graphs and can be obscured by the longer lengths of the time the graph represents. The type of analysis performed here may not reveal the benefits of small-scale, intermittent intervention, such as placing sand on the beach and dunes and planting dune grass. The data also suggest that continuous intervention, such as sand mining, does have a negative effect in the sediment budget. When practices such as sand mining are ceased erosion rates taper off.

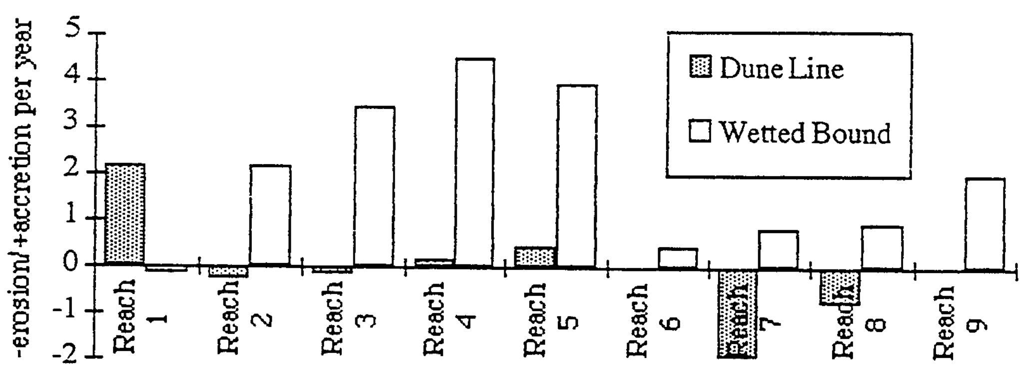
The data suggest that natural seasonal changes in the wetted bound, in the long term, overwhelms the effects of human intervention into this sediment budget. This can be shown in the graph below. The 1938-92 graph for the wetted bound shows accretion over the 54 year span this is what might be expected since Ocean Beach is the beach and frontal dune to a massive dune field which lies beneath the urbanization of San Francisco.

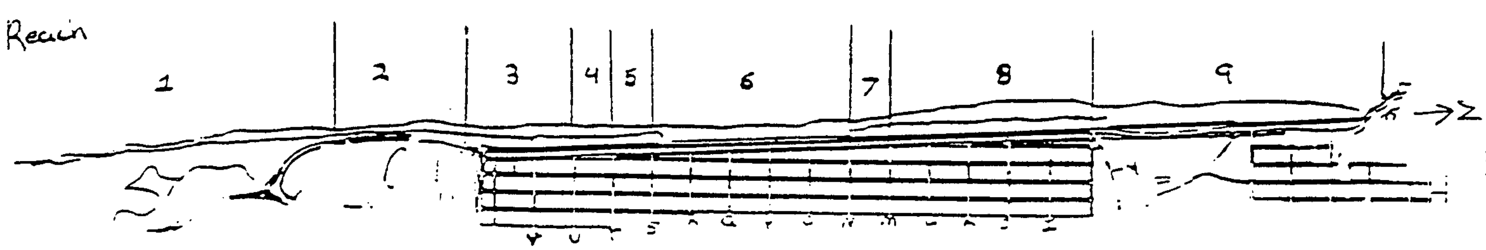
The graph below shows mainly erosion for the over all dune line. However, the dune line was created as part of the continuing construction of the Great Highway. This fill extended

the high water shoreline approximately 250 feet seaward and may have altered the equilibrium of the beach. It has been suggested that this erosion is the beach attempting to regain equilibrium to a pre-fill (1852) state [US1]. This may explain the long term erosion for the dune line in graph below. If the artificial dune that the great highway is constructed on was allowed to erode, the beach may reach an equilibrium approximately 250' landward of the seaward edge of the Great Highway fill. Of course, this action would compromise not only the Great Highway itself and the sewage transport box, but also public and private structures that are constructed east of the Great Highway. It is this artificial dune that has afforded protection from the waves so that structures could be built without concern for wave erosion. So it is this artificial dune that is the focus of most of the erosion control measures on Ocean Beach.

The recorded total amount of sand placed on Ocean Beach since 1927 is approximately 2,000, 000 cubic yards. The recorded amount of sand removed by sand mining since 1963 is 100,000 cubic yards. Therefore the amount of sand that was dumped is greater than the amount removed. This may be reflected in the overall low erosion rates of the dune and the accretion rates in the wetted bound.

Long Term Analysis for Dune Line and Wetted Bound 1938-92





12. Recommendations

This study suggest that the GGNRA continue their current sand management practices and that the City Of San Francisco and the Corps of Engineers San Francisco District continue to work closely with the GGNRA in developing a dune nourishment program for Ocean Beach.

APPENDIX - B

ECONOMIC ANALYSIS

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

OCEAN BEACH
STORM DAMAGE REDUCTION-- FEASIBILITY STUDY
ECONOMIC EVALUATION OF PROJECT BENEFITS
SEPTEMBER 1996

PURPOSE

This report evaluates the National Economic Development (NED) benefits for providing storm damage protection in the area of Ocean Beach in San Francisco, California. The benefits are presented using 1995 price levels and a current (FY96) Federal Discount Rate of 7.625%. Also mentioned in the report are the economic data, necessary assumptions used to evaluate the proposed plans for protecting Ocean Beach. Depending on the assumptions used, the average annual benefits vary from $4.5 million to $6.8 million.

STUDY AREA

Ocean Beach is found in the City and County of San Francisco and runs approximately 3.6 miles from the Cliff House in the north to the Fort Funston bluffs in the south. Previous reports identified three areas, or "reaches" which are subject to potential damage. The first reach extends from Moraga Street to Noriega Street and is approximately 870 feet long. The second reach extends along Santiago Street and is approximately 300 feet long. The third reach begins 80 feet north of Sloat Boulevard and extends to 2,680 feet south of Sloat Boulevard.

PROBLEM IDENTIFICATION

The potential for storm damage exists in the study area. Large and steep winter waves can erode much of the high-water shoreline and narrow the beach. Simultaneously, severe storms can erode the backshore dunes at Ocean Beach which serve to protect and support the Great Highway and the Lake Merced Transport Box.

The major storms in 1983 removed 60 feet of protective dune and threatened the Great Highway in a matter of days. Without protection, a storm of equal size could damage the Great Highway, forcing it to close and causing long traffic backups, inconvenience, traffic reroutes, and extra travel until repairs could be made. In addition, a storm of greater strength than that of 1983 could break the Lake Merced Transport Box, creating an ecological disaster that would be difficult to correct, and costing the City millions of dollars in damages.

Previous studies showed that all three reaches would be impacted by erosion or storms within the 50-year life of the project. This study has developed a risk-based model of the expected erosion which is believed to provide a more accurate representation of future conditions. Based on the risk analysis, only Reach III is expected to be impacted within the project life.

Reaches I and II are expected to be affected in 90 years and 55 years, respectively. While the main focus of this analysis is on Reach III, a sensitivity analysis was performed for Reaches I and II (Appendix C). The Corps of Engineers identified several alternatives for protecting Reach III. They include a dune nourishment program, an O'Shaughnessy type seawall and a Taraval type seawall. It is believed that all plans will provide equivalent levels of protection.

Public Facilities

Four major public facilities are found in the study area. They are the Great Highway, the Westside Transport Box, the Lake Merced Transport Box, and public parking lots in Reach III. If these facilities are endangered due to storm and wave erosion, the City and County of San Francisco would act accordingly to repair the damage and protect them from future damage, although the protection would not be permanent.

a. Great Highway

Historically, the Great Highway has been subject to damage and even closure from storm erosion removing the protective dunes and undercutting the highway. The most recent occurrences were in 1978-79 and 1984. Under present erosion rates, Reach III is expected to experience damages in as little as three years. Reaches I and II are expected to be impacted in 90 and 55 years, respectively.

b. Westside Transport Box

The Westside Transport Box is a major component of the City's waste water management system. Completed in 1983 at a cost of $60,000,000, its replacement cost today, as estimated by the City, would be $73,000,000. The transport box is entirely beneath the Great Highway, specifically, 40 feet east of the southbound lanes of the Upper Great Highway.

Previous studies showed that the transport box would be seriously damaged without a project. Further technical analysis, however, shows that the transport box will not be threatened by erosion or storms. Therefore, no potential damages were calculated for the transport box.

c. The Lake Merced Transport Box

The Lake Merced Transport Box was completed in 1993 at a cost of $22,900,000. The 8,500-foot long box is 30 feet east of the southbound lane, under the Great Highway Extension. The likelihood that the transport box will be damaged once erosion has reached the center of the parking lots is 15 percent; the likelihood that the box will be damaged once erosion encroached on the Great Highway is 22 percent.

d. Public Parking Facilities South of Sloat Boulevard and Associated Recreational Opportunities

Reach III contains two parking facilities, which total approximately 44,000 square feet and hold 220 parking spaces. According to the City's Department of Public Works, it would cost $838,000 to reconstruct these parking facilities if damaged. A sanitary facility is also found there and was constructed at a cost of $440,000. Based upon the forecasted rate of erosion for Reach III, these facilities are expected to be affected in one year. Once affected, these facilities would need to be repaired annually.

GENERAL METHODOLOGY FOR EVALUATION

The economic evaluation of each benefit category is accomplished in the generally accepted "with" and "without" project framework of a federal project. In this regard, the without project condition means the local interest will act to repair damages and protect the Great Highway, the Lake Merced Transport Box, and the parking facilities, although such remedial protection is not considered permanent. Besides the damages, there would be losses associated with travel delays, extra distances traveled because of the rerouting of traffic, environmental damages measured by fines levied by the Environmental Protection Agency (EPA) for polluting nearby waters, and the loss of recreation.

The with project condition provides for the prevention of these losses and achieves those savings associated with the project. The resulting savings represent the National Economic Development (NED) benefits. The evaluation is dependent upon specific erosion rates developed by the Corps based upon extensive modeling and studies of erosion in the project area. For this analysis, there are two sets of benefits. This is because the local interest is faced with two options. They could decide not to repair the parking lots and wait until the Great Highway is impacted before taking action. While this decision is would be premised on a "let nature take its course" philosophy and would not entail repairs to the parking facilities; however, the loss of the parking facilities will undoubtedly impact the recreation at Ocean Beach. Alternatively, the local interest could take action immediately once the erosion problem reaches the parking facilities. The recreation losses and potential damages are lower under this choice, but the local interest must incur additional expenses to repair such facilities. These two choices are considered "scenarios" rather than alternatives from the Corps perspective as the action a choice would be determined at the local level.

The erosion rate assumptions under the two scenarios:

Scenario 1: *(If only the road is repaired)*:

- There is a 100% likelihood southbound lanes of Great Highway will be impacted.
- There is a 22% likelihood that the northbound lanes and the Lake Merced Transport Box will be impacted.

Scenario 2: (If the parking lots are repaired):

- There is a 36% likelihood southbound lanes of Great Highway will be impacted
- There is a 15% likelihood that the northbound lanes and the Lake Merced Transport Box will be impacted.

These percentages are based on the risk modeling done for this report.

Benefit Categories:

Eight benefit categories have been identified for evaluation in this report. These are:

(1) Value of Travel Time Delays (Southbound Great Highway)
(2) Extra Distances Driven (Northbound-Great Highway)
(2a) Associated Value of Time Delay
(3) Value of Travel Time Delays on Other Arterials
(4) Elimination of Costs to Repair the Great Highway
(5) Elimination of Costs to Repair Lake Merced Transport Box
(6) Elimination of Two Parking Facilities and Associated Recreational Opportunities
(7) Elimination of Environmental Degradation and Fines
(8) Prevention of the Loss of Recreation and Enhancement of Recreation Opportunities

The benefit categories are discussed below:

(1) Value of Travel Time Delays (Southbound) Due to Closure of Great Highway

When erosion has progressed to within 10 feet of the Great Highway, the southbound lanes would merge from two lanes to one, creating delays for motorists traveling southbound on the Great Highway.

Estimate of Minutes of Delay San Francisco's Bureau of Traffic Engineering estimated an average delay time of five minutes for motorists merging onto the available southbound lane during non-peak hours. During peak hours, the traffic on the southbound lanes would be backed up, creating an 18-minute delay. This estimate was based on motorists seeking the following alternative routes: Lower Great Highway, Sunset Boulevard, and 19th Avenue. The 18-minute time delay was based on a motorist using the Great Highway as a thoroughfare to the Golden Gate Bridge or other points in San Francisco east of 19th Avenue. If a motorist were traveling to or from a point such as the Cliff House or another destination in the Northwestern portion of the City, the delay resulting from the loss of the Great Highway would be longer.

Value of Time Delays The value of time delays was based upon data obtained from the California Department of Transportation and a procedure contained in a USACE report titled, "Value of Time Saved for Use in Corps Planning Studies, a Review of the Literature and Recommendations" IWR Report No. 91-R-12, October 1991. The value of time for this study was $0.149 per minute of delay. Details of this derivation are contained in Appendix A.

Traffic count data were also obtained from the City's Bureau of Traffic Engineering. According to the most recent traffic count performed in October 1993, 18,410 autos used this segment of the road in a 24-hour period. This count refers to traffic in both directions-- 9,525 autos traveling northbound and 8,885 autos traveling southbound. Of the 8,885 autos moving southbound, 4,326 autos would incur 5-minute delays during non-peak hour traffic. The remaining 4,559 autos would incur 18-minute delays, during peak hour traffic. The extent of the delay depends upon whether the traffic is peak or non-peak hour traffic.

The following parameters and procedures are used to calculate delay cost, which amounts to $1,854,000 ($387,000 non-peak; $1,467,000 peak), assuming that the local interest will not repair the parking lots and $667,000 if the local interest repairs the parking lots.

Autos traveling southbound	8,885
Non-peak hours	4,326
Peak hours	4,559
Average delay for merging (non-peak hours)	5 min.
Average delay per affected auto (peak hours)	18 min.
Days affected	120 days
Costs of delay:	$0.149

(# of autos) × (mins. of delay) × (days) × (value of delay/mins) = Total

Non-peak hours: (4,326) (5) × (120)× ($0.149) = $387,000

Peak hours: (4,559) × (18) × (120) × ($0.149) = $1,467,000

Scenario 1: (Assuming parking lots will not be repaired)

There is a 100 percent chance the parking facilities will be destroyed during the year.

(Travel Time Delay Cost) × (Probability of occurrence)

Total: ($387,000 + $1,467,000) = ($1,854,000) × (1.00) = $1,854,000

Scenario 2: (Assuming parking lots will be repaired)

There is a 36 percent chance the parking facilities will be destroyed during the year.

(Travel Time Delay Cost) × (Probability of occurrence)

Total: ($387,000 + $1,467,000) = ($1,854,000) × (0.36) = $667,000

(2) Extra Miles Driven Due to Closure of Great Highway (Northbound)

This category of benefits applies to automobiles with a destination in the Northwestern portion of the City. Motorists who use the Great Highway as a thoroughfare to the Golden Gate Bridge would not incur additional miles if the Highway were lost. However, motorists intending to reach the Cliff House would need to use alternate routes. Some motorists could take Sloat Blvd. to Sunset Blvd., and then follow Sunset north and head west on Lincoln Way to the

northern portion of the Great Highway. This represents an additional two miles. Other motorists could use 19th Avenue instead of Sunset Boulevard, which represents an additional four miles. Thus, an average of three extra miles per auto trip was used for this analysis. Figure 1 displays each of the alternative routes.

The evaluation is based upon the number of affected automobiles, the average extra distance driven, the costs of driving those extra miles, and the number of days that motorists need to drive the extra distances. An estimated 6,375 autos will travel northbound during times when the Cliff House is open. This represents 2,327,200 affected autos per year. Since 10 percent of the autos have a Cliff House destination, 232,700 autos would need to drive extra distances due to the closure of the Great Highway.[1] The costs of automobile operations in 1995 were obtained from information published by the American Automobile Association (AAA). An average cost of 41.2 cents per mile was selected based upon an average motorist driving 15,000 miles per year.

If the City does not repair the parking lots, then there is a 22 percent probability that the northbound lanes of the highway will be impacted by flooding. If the City repairs the parking lots, the likelihood of highway being impacted is 15 percent. The extra distance costs are $21,100 and $14,400, depending on whether the City repairs the parking lots.

Number of auto trips per year:	232,700
Average extra miles per auto trip:	3 miles
Extra miles per year:	698,100

Value of extra distance: ($0.412) × (698,100) × (4/12) = $95,900

(Extra distance value) × (Probability of damage) = (Benefit)

Scenario 1: (Assuming that the parking lots will not be repaired):

There is a 22 percent chance of damage if the parking facilities are not repaired.

(Extra distance value) × (Probability of damage) = (Benefit)

$95,900 × 0.22 = $21,000

Scenario 2: (Assuming that the parking lots will be repaired):

There is a 15 percent likelihood of damage if the parking facilities are repaired.

(Extra distance value) × (Probability of damage) = (Benefit)

$95,900 × 0.15 = $14,000

[1] Analysis of data on Cliff House visitation data indicated that 32 percent of the auto trips access the Cliff House from a point where they would use the Great Highway traveling north. This approach results in only a partial estimate of extra miles that would be driven, as there has been no estimate of the autos that would approach the Cliff House from other points of origin, and then experience delays when they could not leave the Cliff House and use the Great Highway to travel to points south.

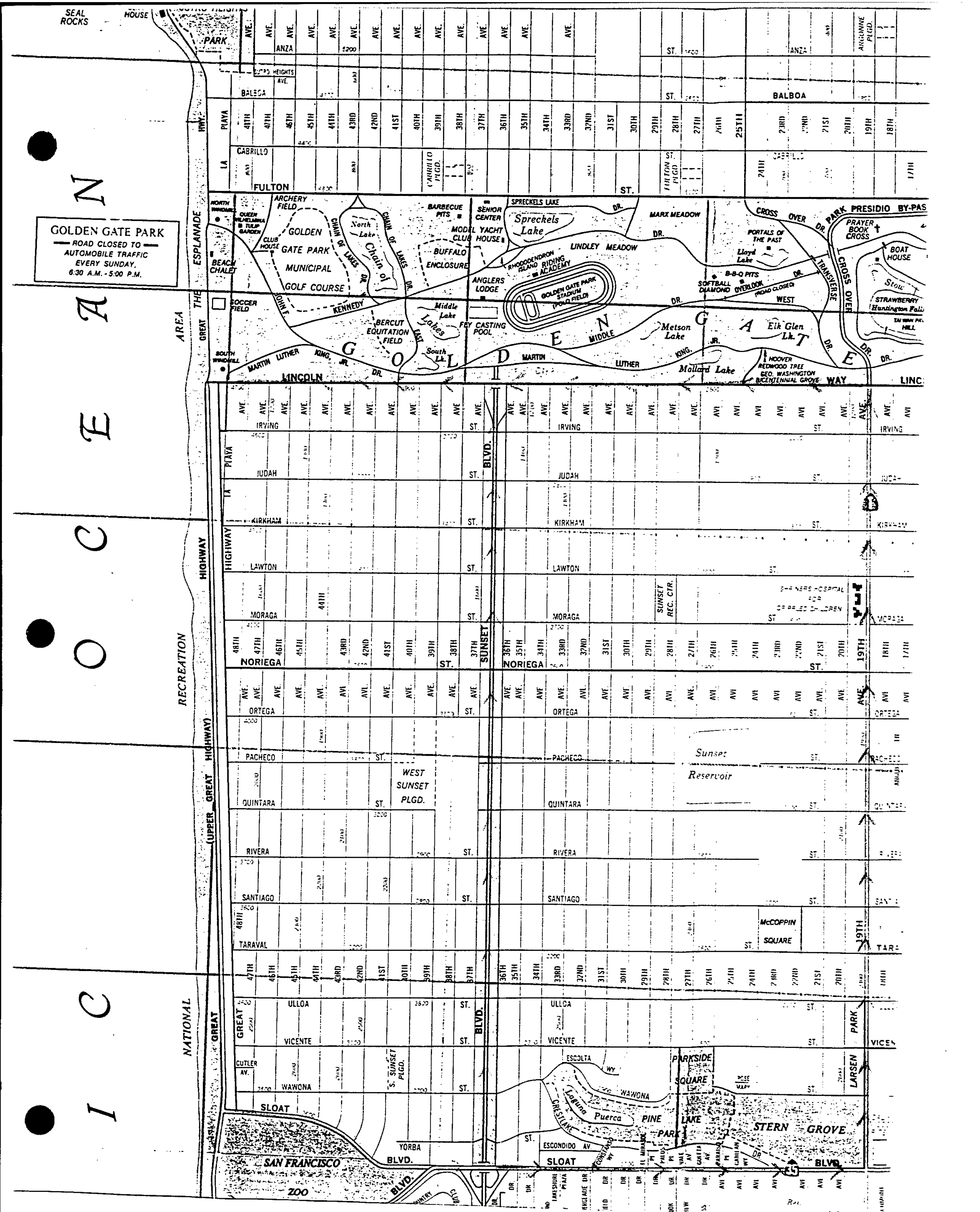


Figure 4) Ocean Beach Storm Damage Reduction Study

(3) Time Delays Associated with Extra Miles Driven (Northbound)

By using alternative routes, motorists would experience delays on roads already filled their capacity. This increased congestion not only makes cars idle longer and consume excess gasoline, it also threatens the safety of pedestrians. The length of delay is approximately three minutes and the delay cost is \$0.149 per minute (See Appendix A). Table 2b shows how the time delay costs were computed for motorists using alternative northbound routes. If the City does not repair the parking lots, the value of time delays is approximately \$23,000; if the City repairs the parking lots, the value is \$15,600.

(# of autos) × (Amount of time delay) × (Value of delay per minute) × (# of days of delay)
232,700 × 3 minutes × \$0.149/minute × 120/360 days = \$ 34,700

Scenario 1: (Assuming parking lots are not repaired):
There is a 22 percent chance of damage if the parking facilities are not repaired.
(Value of time delay) × (Probability of occurrence) = (Benefit)
\$34,700 × 0.22 = \$ 7,600

Scenario 2: (Assuming parking lots are repaired):
There is a 15 percent chance of damage if the parking facilities are repaired.
(Value of time delay) × (Probability of occurrence) = (Benefit)
\$34,700 × 0.15 = \$ 5,200

(4) Value of Travel Time Delays on Other Arterials

The value of time delays is based on the number of autos affected by the rerouted traffic during peak hours only. If the Great Highway were to close, traffic would be rerouted to two main arterials, Sunset Boulevard and 19th Avenue. Consequently, the eastbound and westbound routes would become congested.

Given its proximity to the points of diversion, the traffic count at 41st Street was considered more representative of the number of autos incurring additional traffic delays rather than a count further east. However, because of the direction of the diversion, only the eastbound traffic (5,600 autos) would be affected. The traffic that uses the Lower Great Highway between Lincoln Way and Sloat Boulevard is estimated to be 3,700 (1,900 northbound and 1,800 southbound), but only the southbound traffic (1,800 autos) would be affected. The average daily traffic between Lincoln Way and Sloat Boulevard is estimated to be 37,700. This northbound traffic, numbering 18,000 autos, will be impacted. Therefore, the total number of autos that would be detrimentally impacted is 25,400 (5,600 + 1,800 + 18,000).

The City's Traffic Engineering Division indicated that the delays caused by the traffic diversions mentioned above would be five minutes long. Information from the Bureau of Traffic Engineering indicated that of the 25,400 autos potentially impacted, only the peak hour traffic (7,620 autos) would incur the delays. This inconvenience will last about 120 days. With each

minute of delay costing a motorist $0.149, the total cost of time delays on other arterials is $681,000 if the parking lots are not repaired and $245,000 if the parking lots are repaired, given the 36% likelihood that the road will be impacted.

Estimated total delay costs:

Autos × time delay × # of days × cost per delay = time delay cost
7,620 × 5 minutes × 120 days × 0.149 = $681,000
(Estimated total delay cost) × (Probability of occurrence)

Scenario 1: (Assuming parking lots are not repaired):
There is a 100 percent probability of damage if the parking facilities are not repaired.

(Estimated total delay cost) × (Probability of occurrence)
$681,000 × 1.00 = $681,000

Scenario 2: (Assuming parking lots are repaired):
There is a 36 percent probability of damage if the parking facilities are repaired.

(Estimated total delay cost) × (Probability of occurrence)
$681,000 × 0.36 = $245,000

(5) Elimination of Costs to Repair the Great Highway

The repair costs are based upon the costs of repairing a specified length of the Great Highway. The current cost of repairing the highway on a lineal foot basis was obtained from the Department of Public Works (DPW), City and County of San Francisco. It is a 1995 value and is estimated to be $2,391 per lineal foot. If the entire length of each reach had to be repaired annually, i.e., 870 feet for Reach I, 700 feet for Reach II, and 2,680 feet for Reach III, the damage evaluation would be based on the length in each reach multiplied by cost per lineal foot. However, the best estimate is that only part of each reach would be affected each year; this was estimated to be 75 percent for Reaches I and II, and 25 percent for Reach III. These annual values are subsequently discounted to take into account when the repair is made and then annualized.

The following presents the repair cost calculations for the assumptions mentioned earlier. If the City decides not to repair the parking lots, the damage is $1,602,000; if the City repairs the parking lots, the damage is $577,000.

Total Repair Cost: Great Highway Repair Costs Reach III:
(2,680 feet) × (.25) × ($2,391) = $1,602,000
(Total Repair Cost) × (Probability of Occurrence) = (Benefit)

Scenario 1: (Assuming parking facilities will not be repaired):
There is a 100 percent chance of damage if the parking facilities are not repaired.

(Total Repair Cost) × (Probability of Occurrence) = (Benefit)

$1,602,000 × 1.00 = $1,602,000

Scenario 2: (Assuming parking lots will be repaired):
There is a 36 percent chance of damage if the parking facilities are repaired.

(Total Repair Cost) × (Probability of Occurrence) = (Benefit)

$1,602,000 × 0.36 = $577,000

(6) Elimination of Costs to Repair the Lake Merced Transport Box

The costs to repair the Lake Merced Transport Box were obtained from the City and County of San Francisco's Department of Public Works. For purposes of evaluating the claimed NED benefit, the repair costs were considered to be equal to the removal and replacement costs of the affected area. If part of the transport box is damaged, it will need to be removed at a cost of 50 percent of its construction and then replaced. The benefit derivations are presented below.

(Construction cost) × (Length of Hwy.) × (1.5) = Total cost

$22,900,000 × 2,375/8,500 ft × 1.5 = $9,598,000

(Total cost) × (Probability of occurrence)

Scenario 1: (Assuming parking lots will not be repaired):
There is a 22 percent likelihood of damage if the parking facilities are not repaired.

$9,598,000 × 0.22 = $2,112,000

Scenario 2: (Assuming parking lots will be repaired):
There is a 15 percent likelihood of damage if the parking facilities are repaired.

$9,598,000 × 0.15 = $1,440,000

(7) Elimination of Loss of Parking Facilities and Associated Recreational Opportunities

A. Repairs to the Parking Facilities

Based on current erosion rates, two parking lots and a sanitary facility would be impacted in one year. The parking lots total 44,000 square feet and are an important component of the Ocean Beach public facilities. The current (1995) costs to construct the parking facilities, obtained from the City's Department of Public Works, were estimated to be $838,000. Costs for the sanitary facility were obtained from the National Park Service and were estimated to be $440,000, bringing the total cost to $1,278,000. This is considered an annual cost once the

facilities are impacted.

B. Loss of Recreational Opportunities

Besides the damages, recreational activities associated with the use of these lots would be lost once the parking facilities were destroyed. Given the present erosion rates in Reach III, the facilities would be destroyed in one year unless the road is repaired. The loss of the parking lots and sanitary facilities would adversely limit the recreational uses of Ocean Beach. Discussions with National Park Service (NPS) personnel indicate that the loss of the parking and sanitary facilities would reduce the number of recreational users by 25 to 50 percent. For this evaluation, a 25 percent reduction was used in estimating recreational losses. The estimated number of recreational visitors who use the parking facilities annually is 1,242,000. These recreational losses would occur annually once the parking lots and sanitary facilities are impacted in 1999. According to Economic Guidance Memorandum 95-3, the unit value per visit for generalized recreation ranges from $2.44 to $7.34 per visit. The $2.44 represents a 0 point value while $7.34 represents a point value of 100. For this analysis, a point value of 50 or $5.24, was used (Appendix B).

If the local interest decides not to repair the parking lots, the only measurable impacts would be the lost recreation opportunities (there would be no repair costs). If the local interest decides to repair the parking lots, there would be two benefits to a project, the savings in costs to repair the parking lots and sanitary facility, and the savings in lost recreational opportunities. It will take an estimated three months (1/4 a year) to repair the parking lots. Therefore, the lost recreation benefits for are 1/4 the annual recreation losses. These losses amount to $1,627,000 or $1,685,000, depending on the assumption used.

Scenario 1: (Assuming parking lots will not be repaired): The benefits were comprised of lost recreational opportunities only.

# of Visits × Percent Reduction × Unit Value of Visit
1,242,000 × 0.25 × $5.24 = $1,627,000

Scenario 2: (Assuming parking lots will be repaired):
The benefits are comprised of the lost recreation and the repairs to the parking facilities.

Savings in Costs to Repair Parking lots and Sanitary Facility: $838,000 + $440,000 = $1,278,000

Recreation Benefits: # of Visits × Percent Reduction × Unit Value of Visit × Length of Year
1,242,000 × 0.25 × $5.24 × 1/4 = $407,000

Total Benefit: $407,000 + $1,278,000 = $1,685,000

(7) Elimination of Environmental Degradation

Once the Lake Merced Transport Box is breached, sewage would be discharged onto nearby shore waters. According to the Environmental Protection Agency (EPA), the fines for sewage pollution will be $25,000 per day. While the $25,000 amount represents an economic transfer, it also serves as a proxy for the damage it would cause. It would take 60 days to repair the breached transport box. The following displays the total losses due to environmental degradation which are $330,000 and $225,000 for the established assumptions. These losses do not include civil lawsuits, epidemic, and adverse impacts to marine life.

Scenario 1: (Assuming parking lots will not be repaired):
There is a 22 percent chance that the transport box will be damaged.

(Amount of Fine) × (# of Days) × (Prob. of Occurrence)

($25,000) × (60) × (0.22) = $330,000

Scenario 2: (Assuming parking lots will be repaired)
There is a 15 percent chance that the transport box will be damaged.

(Amount of Fine) × (# of Days) × (Prob. of Occurrence)

($25,000) × (60) × (0.15) = $225,000

SUMMARY OF ANNUAL BENEFITS

The following tables presents the benefits, by category, under the two scenarios. The first scenario assumes that the parking facilities will not be repaired. The second scenario assumes the parking facilities will be repaired.[2] The average annualized values were determined using the current Federal Discount Rate of 7.625% and a fifty-year project life. If the parking facilities are not repaired, we can expect greater damages and travel delays than if the parking facilities are not repaired. The average annual benefits are $6.8 million and $4.5 million for the first and second scenarios, respectively.

Ocean Beach Storm Damage Reduction Project
Scenario 1 (Parking facilities will not be repaired)

Category	Benefits	Yrs. until Impact	Annualized Benefits
(1) Time Delay Costs (Southbound)	$1,854,000	3	$1,478,000
(2) Extra Distance Cost (Northbound)	$21,000	3	$16,700
(3) Time Delay Costs (Northbound)	$7,600	3	$6,000
(4) Time Delay Costs (Other Arterials)	$681,000	3	$542,700
(5) Great Highway Repair Costs	$1,602,000	3	$1,277,000
(6) Lake Merced Transport Box Repair Costs	$2,112,000	3	$1,683,000
(7) Lost Recreation Activities	$1,627,000	1	$1,509,000
(8) Environmental Degradation & Fines	$330,000	3	$263,000
Total			$6,775,000

[2]The annualized benefits were derived through the following formula:
(Undiscounted Benefit) × (Present Worth --Single Payment 3 Years)
× (Present Worth-- Uniform Annual Series-47 yrs.) × (Capital Recovery Factor-50 Years)

Ocean Beach Storm Damage Reduction Project
Scenario 2 (Parking facilities will be repaired)

Category	Benefits	Yrs. until Impact	Annualized Benefits
(1) Time Delay Costs (Southbound)	$667,000	1	$618,000
(2) Extra Distance Cost (Northbound)	$14,000	1	$13,000
(3) Time Delay Costs (Northbound)	$5,200	1	$4,800
(4) Time Delay Costs (Other Arterials)	$245,000	1	$227,000
(5) Great Highway Repair Costs	$577,000	1	$535,000
(6) Lake Merced Transport Box Repair Costs	$1,440,000	1	$1,335,000
(7) Lost Recreation Opportunities	$407,000	1	$377,000
(8) Repairs to the Parking Facilities	$1,278,000	1	$1,185,000
(9) Environmental Degradation & Fines	$225,000	1	$209,000
Total			$4,504,000

(APPENDIX A) DETERMINATION OF VALUE OF TRAVEL OF TIME:

In the Reconnaissance Report, the average cost of a given delay was obtained from the California Department of Transportation (CALTRANS) and was estimated to be 12 cents per vehicle-minute. Factors taken into account in deriving this value are: average wages, additional miles driven, idling, and extra gasoline consumption. The 12 cents per minute costs are based on an average occupancy of 1.2 people per vehicle. This value is used by CALTRANS in all of their economic studies. CALTRANS does not plan to change this value in the foreseeable future.

For the Feasibility Report, the district derived delay cost through a procedure contained in USACE. Institute for Water Resources report IWR Report 91-R-12 October 1991, "VALUE OF TIME SAVED FOR USE IN CORPS PLANNING STUDIES, A REVIEW OF THE LITERATURE AND RECOMMENDATIONS." This procedure, which had been recommended by the Office Chief of Engineers, CECW-PD, incorporates median income and social/recreation values to estimate the value of time saved (dollars per hours). The 1994 median income was obtained from a Sales and Marketing Management Survey of Buying Power and the Survey of Current Business for 1994 and was estimated to be $38,308 per family or $18.42 per hour ($38,308/2080 hrs.).

A set of recommended values of time saved were based on four different trip purposes (see Appendix B); low time savings (0-5 minutes), medium time savings (5-15 minutes), high time savings (more than 15 minutes), and vacations. These values were weighted with the distribution of trip purposes from the Metropolitan Transportation Commission. The distribution of trip purposes was 21 percent work related, 48 percent personal business and 31 percent social/recreation. The resulting value was a weighted hourly delay cost of $8.95 per hour or $0.149 per minute of delay.

(APPENDIX B) DERIVATION OF RECREATION BENEFITS:

Information from the National Park Service (NPS) indicated that most of the users reside in the City and nearby communities. It is not a regional park attracting recreationists from all over the San Francisco Bay Area, although some users do come from the other near v counties plus visitors from other states and countries. The identified recreation activities are of a general recreation nature. Ocean Beach is a small recreation area, and based upon information from the NPS indicate that there will be little impact on the users of the beach. It is therefore that the Unit Day Value of evaluating recreation benefits was used. The points assigned to the project site were developed with the assistance of staff of the NPS. Under project conditions, the increase was only $0.25 or 5 percent of the without project unit day value of $4.86. The Unit Day Value approach was considered reasonable to use though the annual visitation exceeded the 750,000 annual visitations contained in the guidance.

Economic Guidance Memorandum # 94-3 specifies that a range of unit day values applicable to Fiscal Year 1995 is as follows: $2.44 to $7.34 for General Recreation. The $2.44 value corresponds to the a zero point value and $7.34 corresponds to a point value of 100 per ER 1105-2-100 (28 Dec 90). As specified in the ER, the following five criteria are used to determine a final point value:

Maximum Points	
a) Recreation Experience	30
b) Availability of Opportunity	18
c) Carrying Capacity	14
d) Accessibility	18
e) Environmental	20
Total Possible	100

Interviews with National Park Service rangers that observe recreation activities and maintain the Ocean Beach area, and field observation by Corps personnel, formed the basis for assigning point values to the general recreation day. ER1105-2-100 states those estimates of annual use are combined with the selected unit day values to estimate recreation benefits. A discussion of the assignment point values General Recreation, follows:

a) Recreation experience (30 points maximum): Several general activities take place on Ocean Beach; one activity, surfing, is classified as high quality. A point value of 13 was assigned to recreation.

b) Availability of opportunity (18 points maximum): Several other locations that offer the same type of General Recreation are within one hour travel time; a few are within 30 minutes travel time. Assignable value range: 0-3. A point value of 2 was assigned. The population of City of San Francisco in 1993 was estimated at 752,000. The automobile population was 325,766. The number of persons per auto for the City was 2.3. Public transportation takes recreationists within walking distance to the beach and the ample

parking facilities makes it possible for many from the City and the nearby communities to use Ocean Beach. Assignable value range: 0-3.

c) Carrying capacity (14 points maximum): Ocean Beach is classified as a Basic Facility at which to conduct shoreline recreational activities.

d) Accessibility (18 points maximum): The study area has good access, with high quality roads leading to the site, and is readily accessible by public transportation facilities.

e) Environmental (18 points maximum): The study area has above average to outstanding aesthetic quality; i.e., the Pacific Ocean. However, factors do exist that lower the aesthetic quality. Examples are: a busy highway nearby, proximity to a congested urban area, and very heavy use during peak times.

APPENDIX C SENSITIVITY ANALYSIS:

The following is a tabulation of the potential benefits for Reach I on an undiscounted basis. The time delay costs for the Great Highway and on other arterials are the same for Reaches I and II. Remember that the cost to repair the Great Highway varies upon the length of the segment of highway. For Reach I, the repair costs are expected to be $1,560,000 (870 feet × 0.75× $2,391). For Reach II, the repair costs are approximately $1,255,000 (700 feet × 0.75 × $2,391). The total benefits are $4,125,000.

Reach I
Summary of Potential Annual Benefits, Undiscounted

Time Delays Costs (Southbound)	$1,854,000
Extra Distance Costs (Northbound)	$14,400
Time Delay Costs (Northbound)	$15,600
Time Delay Costs (Other Arterials)	$681,000
Great Highway Repair Costs	$1,560,000
TOTAL UNDISCOUNTED BENEFITS	$4,125,000

Reach I
Discounted Benefits

The benefits for saving Reach I (through the beach nourishment alternative) will not be realized until 90 years after project completion. Furthermore, there is no way of knowing what the traffic counts will be 90 years from now. This analysis used the most recent traffic counts and 1995 price levels. The benefits amount to approximately $5,500.

($4,125,000) × (0.00134) = (Present Worth- 90 years) = $5,500

Reach II
Summary of Potential Annual Benefits, Undiscounted

The following presents the potential benefits for Reach I on an undiscounted basis. The total benefits are $3,820,000.

Time Delays Costs (Southbound)	$1,854,000
Extra Distance Costs (Northbound)	$14,400
Time Delay Costs (Northbound)	$15,600
Time Delay Costs (Other Arterials)	$681,000
Great Highway Repair Costs	$1,255,000
TOTAL UNDISCOUNTED BENEFITS	$3,820,000

Reach II
Discounted Benefits

The benefits for saving Reach II (through the beach nourishment alternative) will not be realized until 55 years after project completion. The benefits amount to approximately $67,000.

($3,820,000) × (0.01757) = (Present Worth- 55 years) = $67,000

APPENDIX - C

ENVIRONMENTAL ANALYSIS

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

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APPENDIX C1

Brief Summary

SUMMARY OF ENVIRONMENTAL INFORMATION

* A "Preliminary Environmental Assessment (EA) for the Ocean Beach Storm Damage Reduction Study" (March 1992) was presented in the Reconnaissance Study report dated March 1992. This EA included alternatives such as dune replenishment, quarrystone revetment, concrete seawall, beach nourishment, and No Action.

* An F-3 package (Appendix D2) dated November 1994, includes an environmental write-up that includes the analysis of the above alternatives, and states that the preferred alternative is "to be decided". A "Preliminary Draft Coordination Act Report" (dated September 1993) by the Fish and Wildlife Service (FWS) analyzes the alternatives above, and concludes that dune nourishment is the alternative preferred by the FWS.

* A "Historic Properties Survey" is completed in February 1995, and is attached as Appendix D3.

* A "Social Environment Study" is completed on April 28, 1994, and is attached as Appendix D4.

* <u>May 1995:</u> As of mid-May 1995, a different Corps staff member (Tamara Terry) was assigned to "Ocean Beach Storm Reduction Study", and was asked to begin the preparation of a "Draft Environmental Impact Statement/Environmental Impact Report for the Ocean Beach Storm Damage Reduction Study" once a "preferred alternative" was decided. During the next few months, after numerous letters, memos, and meetings written to, from, and between the Corps team, City & County of San Francisco, National Park Service, etc...the dune nourishment alternative died, was revived, and subsequently, put on hold for further coastal engineering studies (i.e., sediment transport analysis). After it's latest reincarnation, it was finally decided that dune nourishment was not a viable alternative for a long term solution for beach erosion at Reach 3. This was mainly due to the expense and frequency of conducting multiple renourishment of dunes in the affected area once storm damage had occurred.

  After reviewing the project files, attending several field trips and many meetings, I spent a few days (2-3 days) starting several sections on the Draft EIS/EIR. I started using sections I wrote for the "Humboldt Harbor and Bay Deepening Project EIS/EIR", as applicable, for the "Draft Ocean Beach EIS/EIR". None of the sections were ever completed since I spent so few days working on it, but they are enclosed as Appendix D5. Please note that this is a "very rough draft" and much of the information still refers to Humboldt Harbor. I was just going to start working on the "Consistency Determination" when the project died again and all funds were frozen. Sometime soon after this a "Taraval-type seawall" became the alternative to consider in Reach 3.

SUMMARY OF ENVIRONMENTAL INFORMATION (CONTINUED)

* <u>**October 17, 1995:**</u> I prepared a "Scope of Work" (SOW) for the FWS to complete a draft and final "Coordination Act Report" in FY 1996. This is enclosed as Appendix D6. As of this date, the alternatives to be considered were a "Taraval-type seawall" and the No Action Alternative. A few weeks after completing this SOW, we were told the project was dead again until a decision was made by the City & County of San Francisco and National Park Service on which, if any, of the alternative(s) should be examined further in a feasibility study.

The following is information regarding the bank swallow and snowy plover, both of which reside at Ocean Beach:

* **Endangered Species:** The State-listed bank swallow and the Federally-endangered western snowy plover are the only two legally protected species known to be residents of Ocean beach.

<u>***Bank Swallow:***</u> The bank swallow nests at the Fort Funston cliffs located in Reach 3 at Ocean Beach. Any construction activities in Reach 3 should be limited to the "September through March" time frame so as to not disturb resident bank swallows. Construction activity **should be avoided** from the "beginning of April to the end of June" (spring & summer) when bank swallow nesting at Fort Funston cliffs is at it's peak.

<u>***Snowy Plover:***</u> No historic records of the nesting of snowy plovers at Ocean Beach has been obtained by the Corps as of this date. In the past, observations of "territorial behavior" by snowy plovers at Ocean Beach have been reported, and nesting of snowy plovers have been reported at Point Reyes located 30 miles to the northwest of the study area. Due to the high recreational use of Ocean Beach by beach-goers and their unleashed dogs (note: on January 1, 1997 a new policy goes into effect at Ocean Beach that bans off-leash dog walking in the area of Ocean Beach from the south edge of Golden Gate Park to Sloat Boulevard), it is highly unlikely that any successful nesting of snowy plovers occurs at Ocean Beach.

The National Park Service recently reported that approximately 70 snowy plovers winter and rest at Ocean Beach during part of the year. In Reaches 1 and 2, construction activities **should be limited to** a "late April to July " time frame to avoid disturbance of wintering and resident snowy plovers. In Reach 3, construction activities **should be limited to** a "September through March" time frame to avoid any disturbance of snowy plovers resting and feeding in this reach of Ocean Beach. Apparently, snowy plovers inhabit (rest and feed and winter) Reaches 1 and 2 at different times of the year than in Reach 3. With two legally protected species located at Reach 3, the bank swallow and snowy plover, any construction activity **should be limited to** the "September through March" time frame, and this would minimize any impacts to these two species.

APPENDIX C2

Feasibility Conference Package Summary (F3 Package)

US Army Corps
of Engineers

San Francisco District

ENVIRONMENTAL ISSUES & IMPACTS

OCEAN BEACH STORM DAMAGE REDUCTION STUDY

F3 CONFERENCE

November 1994

CONTENTS

§ 0 SUMMARY

This document presents the environmental analysis for the Ocean Beach Feasibility Study that has been developed as of October 1994. The following issues require resolution, refinement in detail, or are simply not yet known:

☼ the preferred alternative;

☼ detailed mitigation for the preferred plan;

☼ archaeological materials buried at Ocean Beach;

☼ California Environmental Quality Act considerations;

☼ transportation scenario for raw materials brought to Ocean Beach;

☼ nesting effort (summertime) of the snowy plover at Ocean Beach; and

☼ the presence of HTRW sites that could become a project liability.

At the conclusion of the reconnaissance study, and at the public meeting for the EIS, dune nourishment was the favored alternative. Feasibility level analysis to date has shown the seawall alternative to be competitive with dune nourishment. If the seawall alternative is carried through to the F4 Milestone as a viable alternative, it will be necessary to re-open the scoping process and USFWS coordination.

§ 1 STUDY AUTHORITIES

Authority for this study comes from the Congress of the United States which has directed the Corps of Engineers to make a study of beach erosion along the shores in San Francisco County, California, by the following resolution adopted on 3 August 1989 by the Committee on Public Works and Transportation, U. S. House of Representatives:

> "Resolved by the committee on Public Works and Transportation of the United States House of Representatives, that the Secretary of the Army, in accordance with Section 110 of the Rivers and harbors Act of 1962, is requested to make, under the direction of the Chief of Engineers, studies of the shores in San Francisco County, California, from the south county line to the Golden Gate Bridge and such adjacent shores as may be necessary, in the interest of providing protection to public facilities, storm damage prevention, and other related purposes."

The requirement for this document is contained the National Environmental Policy Act of 1969, as amended (PL 91-190). Section 102(2)(A) requires Federal agencies to:

> "utilize a systematic interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and decision making which may have an impact on man's environment."

As part of this process, an environmental impact statement [Section 102(2) (C)] or a finding of no significant impact will be prepared.

§ 2 NEED FOR PROPOSED ACTION & BACKGROUND INFORMATION

Ocean Beach is located along the western boundary of the City and County of San Francisco, and serves as a buffer between the Pacific Ocean and the Great Highway and as a recreation area. Since the 1840's this strip of land has been used for transportation and recreation. Toward these purposes, various roadways and buildings have been constructed along the beach. Storms and erosion have continually threatened or destroyed these structures.

In the 1920's, the City of San Francisco planned to design and construct a concrete seawall along the entire Ocean Beach shoreline to protect the highway and to make a boardwalk/amusement tourist area. Economic conditions in the 1930's halted construction after only one mile of the project was completed. This seawall is known as the O'Shaughnessey Seawall, or esplanade, and it extends from north of Fulton Street to Lincoln Way.

The 665-foot long Taraval seawall was constructed in 1940 to protect the pedestrian underpass and the Great Highway. Sand deposition from natural processes has since buried this wall and modified dune habitat covers this reach.

In 1972, the City gave all of the land at Ocean Beach west of the Great Highway right-of-way to the Golden Gate National Recreation Area (GGNRA).

To alleviate pollution of the Pacific Ocean from the discharge of untreated effluent, the City constructed the Westside Sewer Transport Box under the Great Highway in 1983.

In March of 1988, construction of another seawall/promenade was begun to protect the Great Highway and sewer box between Noriega and Santiago Streets from major storms. This new seawall was completed in 1991.

Ocean Beach is subject to direct attack from waves approaching from the southwest to the northwest. High tides accompanied by large waves have caused recession of the dune escarpment along the central and southern portions of the beach. There is acute erosion of the beach and dunes at Moraga and Noriega Streets, Taraval to Ulloa Streets, and from south of Sloat Boulevard to the Fort Funston cliffs. This erosion threatens shoreline improvements, local infrastructure, natural resources, public property and recreational activities. Previous studies have shown that Ocean Beach has experienced shoreline recession and that major storms have eroded and will continue to erode sections of the beach and dunes.

§ 3 ALTERNATIVES

No federal action

The coast would remain in its semi-altered natural state. Erosion of the dune embankment in the project area will continue at the estimated rate of two to five feet per year. Portions of Ocean Beach will continue to erode and the Great Highway and sewer box will be increasingly vulnerable to wave erosion and damage. Blowing sand would continue to impede traffic by causing closure of the Great Highway. These same conditions would also reduce the recreational appeal of the area.

Quarrystone revetment

This alternative involves placing engineered riprap along the slope to an elevation of 20.5 feet above MLLW to protect landward structures from wave forces and currents during storm events. The beaches in front of the revetments would continue to fluctuate in width and the revetment would limit landward encroachment of the ocean and protect the Great Highway and sewer box after the dunes or beach erode.

Noriega

The revetments would only be constructed in the three areas where the potential for damage is high, in the sections from Moraga to Ortega Streets (870 feet), Taraval to Ulloa Streets (700 feet), and from 125 feet south of Sloat Boulevard southward to the Fort Funston cliffs, a distance of 2375 feet. 225

The revetments would be constructed by first removing the existing dunes, installing filter cloth and quarry stone, and then replacing the dunes. Reconstruction of the dunes with surplus sand would restore habitat and serve as mitigation for the project. The dunes would be re-vegetated as described for the dune nourishment alternative.

The revetment alternative has been dropped from further consideration because of the high cost and concerns over public safety.

Seawalls

Three seawalls would be constructed entirely on City property and would only be constructed in the three areas already discussed under the revetment alternative. The wall at Moraga and Ortega Streets would tie into the existing seawall at Ortega Street and the wall in the central reach would tie into the existing Taraval seawall.

N

Construction would involve removing the existing dunes and installing a recurved seawall with steps, similar to the existing seawalls. The sand in excess required for back fill could be used fot project mitigation in the form of dune reconstruction, or beach and dune nourishment. Plantings as described for the dune nourishment alternative would be used to stabilize backfill areas, the dunes, and to create new habitat.

Beach nourishment

In this alternative, three million cubic yards of sand would be used to nourish the beach from Lawton to Vicente Street. Another one million cubic yards would be used for the reach south of Sloat Boulevard. Foredune vegetation would be removed, the sand would be graded to blend with the dune profile, and the beach regraded and extended seaward into the surf zone, 200 - 300 feet from the Great Highway.

The quantity of sand required for this alternative is so large that alternative sources of suitable sand in addition to sources intended for the dune nourishment alternative will be necessary. For these other sand sources, the environmental impacts will need to be assessed and the necessary permits acquired.

Beach nourishment was dropped from further consideration because of the high cost.

Dune nourishment

A minimum dune width of 100 feet is considered necessary to protect the infrastructure. Dune nourishment for the Moraga - Noriega reach would use 65,000 cubic yards of sand to build out to a width of 140 feet those dunes less than that dimension and would build them up to approximately 34 feet above mean lower low water (MLLW), or to the height of the existing dunes. An additional 40 feet, advance nourishment is included to provide five years of protection. Periodic re-nourishment of the dunes with 65,500 cubic yards of sand will be required, on average, to ensure adequate protection.

Dune nourishment for the Taraval - Ulloa and the Sloat Boulevard southward reaches would use 35,000 and 124,000 cubic yards of sand, respectively, to build out to a width of 140 feet those dunes less than that dimension and would build them up to approximately 34 feet above mean lower low water (MLLW), or to the height of the existing dunes. An additional 30 feet and 40 feet respectively, advance nourishment is included to provide four years of protection. On average, periodic re-nourishment of these dunes with a total of 159,000 cubic yards of sand will be required to ensure adequate protection.

The materials used would be imported from Decker Island, CA, Felton, CA, or the San Francisco Bay Presidio Shoal. As required by the National Environmental Policy Act, impacts from sand mining are addressed in the contractor's permit from the Corps of Engineers and are not considered in this environmental document.

Sand transportation would be by truck or barge. The dunes would be contoured with a bulldozer the size of a Caterpillar D-8. Using 30-ton trucks, 9,200 trips would be necessary to supply the sand to the project site. There is an existing haul road at the extreme south end of the beach, but a temporary haul road would be necessary to support the trucks on the beach.

For transportation by barge, a mooring point would be located 2000 feet offshore. The sand would be pumped in a water slurry through a 20-inch diameter polyethylene to the beach. With barges carrying 3077 cubic yards per trip, 106 trips would be necessary to construct the dunes.

The widened dunes will be stabilized by planting with native species found in the dune environment. Since these plants are adapted to this climate, no irrigation is necessary. No mitigation would be required for this alternative since habitat will be created, rather than removed or lost from the system. Another benefit of this alternative is that the dunes are a source of nourishment for the beach.

Preferred alternative

To be decided......

§ 4 ENVIRONMENTAL SETTING

General

Ocean Beach and the adjacent landward areas are used extensively by the public. Surfing, fishing, picnicking, jogging and nature appreciation are some of the uses of the beach. Golden Gate Park and the San Francisco Zoo are nearby. The Great Highway is used for general transportation and recreational motoring. The City and County of San Francisco has several public works projects operating or under construction along the Great Highway corridor.

Study area

The Ocean Beach study area extends from the Cliff House southward 3.6 miles to the Fort Funston Beach and westward from the Great Highway to the Pacific Ocean. Within the study area, the beach varies from approximately 450 feet to 175 feet in width. The average width is about 250 feet and the entire beach area is about 0.18 square mile or 118 acres. The dunes are underlain by sandstone of the Colma Formation. The fore dunes and some of the landward areas are stabilized largely by native and ruderal vegetation. In some areas, especially the downwind edges of the dunes, there is wind erosion. In the southern reaches, storm waves frequently remove sand up to the base of the dune scarp during the winter.

Project area

The areas to be affected by the project are an 870-foot long section of beach from Moraga to Noriega Streets, a 700-foot long section of beach and dune from Taraval to Ulloa streets, and a 2375-foot long section of beach and dune from 225 feet south of Sloat Boulevard to the Fort Funston Cliffs.

Vegetation

The vegetation community can be described as modified coastal strand; a mixture of native and introduced plants which are adapted to salt spray, mist, and blowing and drifting sand. Inundation by sea water only occurs during storm events. European beach grass is the predominant ground cover along the dunes. On the landward side of the dunes, iceplant and European beach grass comprise most of the vegetation. Patches of beach sage and bush lupine are the most obvious native species.

The seaward slopes of the dunes and some of the flatter spots in front of them have small colonies of sea rocket, yellow sand verbena, and common butterweed. The remaining flat areas between the dunes and the water have no vegetation. While the extant plant life at ocean beach appears to be exotic, many of the low, slow growing native annual plants still thrive here.

Fisheries

This section of coastline can be described as open-coast sandy beach. This is an extremely harsh environment with no protection from storms. Heavy surf and strong along shore currents seasonally and periodically move large quantities of sand and may drastically change the shape and size of the beach. This marine environment limits the biota to those species of robust constitution, and strong swimming or burrowing abilities. Aggregations of marine organisms that inhabit this niche vary widely in numbers and in distribution. To what extent this variation may be influenced by the physical beach processes is not well understood. This type of exposed beach may be used for spawning by the grunion *Leuresthes tenuis* from March to June or by some members of the smelt family from April to October.

Invertebrate remains found cast on the beach were identified as: rough piddock *Zirfaea pilsbyri,* sand dollar *Dendraster excentricus,* market crab *Cancer magister,* mole crab *Emerita analoga,* spiny sand crab *Blephariapoda occidentalis,* moon snail *Polinicies sp.,* jackknife clam *Tagelus californianus,* and basket cockle *Clinocardium nuttalli.*

Fragments of the red alga *Cystoseria osmudacaea,* the brown alga *Egregia menziesii* and *Laminaria spp.,* and some green algae including sea lettuce *Ulva spp.* were also found on the beach.

While some of this biological evidence on the beach in the study area may be from upcoast habitats, is it reasonable to expect a sand/mud bottom with patches of kelp as the offshore environment.

Wildlife

Due to the urban setting and the sparse vegetative cover, Ocean Beach does not have an abundance of wildlife. Those species which would be directly affected in the project area are those which use the beach as their home. This would affect any dune beetles and other insects which live and burrow into the sand and such reptiles as the western fence lizard, gopher snake, common garter snake and the western toad. Mammals which may use the site are the house mouse, California ground squirrel, California gray squirrel and skunks.

Above the high tide zone, the barren sand is used as a resting and foraging area by several species of gulls. The most common of these are: western gull *Larus occidentalis,* California gull *Larus californicus,* Heerman's gull *Larus heermanii,* and laughing gull *Larus atricilla.* Many common species of birds may also be seen at Ocean Beach. More upland birds such as the raven, killdeer and the American kestrel transit and forage on the beach or in the dunes. The nearby Fort Funston cliffs offer nesting habitat for the bank swallow *Riparia riparia.*

Birds such as gulls, terns and plovers inhabit the beach and shoreline area, but apparently these do not use the dunes for nesting or other habitat. The western snow plover may, however be an exception. At the surf line, sanderlings, godwits and dowitchers may be seen foraging the sand as the waves recede. This indicates the presence of small isopod crustaceans which typically inhabit the upper surf zone.

Water quality

The ocean waters at Ocean Beach are influenced by the California and Davidson Currents, and from the tidal prism from San Francisco Bay. Sediment transport from the Bay produces noticeable increases in turbidity, depending on local conditions. Sea surface temperatures range from 11 - 16°C, and salinities from 22 - 32 $_{ppt}$ just offshore of Golden Gate Park.

Noise

Noise conditions at Ocean Beach are likely to be in the range of 63 - 67 dB, based on the average population density for the City of San Francisco. Noise levels along the Great Highway are in the range of 55 - 85 dB, based on the posted speed of 35 miles per hour.

Hazardous, toxic, & radiological waste

There are no known sites at Ocean Beach, however, no research has been undertaken to confirm this. The sand source investigation tested potential sources for contaminants.

Listed, proposed, candidate & other species

From a list supplied by the USFWS in the spring of 1994, there are 30 species of plants and animals with historic potential to occur at Ocean Beach that could be affected by the proposed project. The State listed bank swallow and the Federally threatened western snowy plover are the only two legally protected species known to be resident at Ocean Beach.

Cultural resources

There were no recorded cultural resources or other culturally significant sites from the prehistoric period identified as a result of the research conducted of State of California and Corps of Engineers records.

Marine archaeology

The primary class of cultural resource of concern to this project is historic-period ships, i.e, the remains of wrecked vessels. Twenty-eight ships have been reported wrecked within the general vicinity of the project reaches on Ocean Beach. It appears that nine of these may be within or near the Area of Potential Effect (APE). Two of the nine possibly within the APE, the *King Philip* and the *Reporter,* have been studied by marine archaeologists and are listed in the National Register of Historic Places as National Historic Landmarks. Additional shipwreck remains are suspected to be within the APE, but their identity is currently unknown.

The Pacific Coast directly south of the Golden Gate is known to have been the site of a number of historic shipwrecks. The most comprehensive examination of information identified 28 "total losses" between Point Lobos, which is just north of the Cliff House, and Point Pedro, 13 miles south, between 1851 and 1926. Nine of these are known to have sunk or been carried onto the beach within the study area. In most cases, the vessels were extensively salvaged before the hulks settled into the beach.

The only recent survey to locate and evaluate shipwrecks in the study area was done in 1987 as part of the Great Highway/Seawall Project. A terrestrial magnetic survey was made of a 2,700-foot long north-south section of the beach between Santiago and Noriega Streets. The surveyed area extended from the western edge of the Great highway westerly into the surf zone. The remains of up to five vessels were located. One of these Vessels, possibly the *Atlantic,* was further studied after sand dune and riprap covering was removed.

It was determined that the seawall construction would not affect any significant historic property.

The Corps has generated a scope of work to effectively locate and identify any shipwreck remains that may be affected by the proposed project. Coordination with the State Historic Preservation Officer is scheduled for the first quarter of FY 95. The National Park Service, because of their expertise in this field and because the GGNRA is within their jurisdiction, has been consulted and asked to assist in the implementation of the study. Once the findings of the recommended work are available, the Corps can determine whether historic properties exist within the areas of effect and the potential impacts from project construction.

Social environment

Social survey completed but text not available yet....

Traffic

Air quality

To be obtained from EPA Region IX....

Recreation

Discussion to be developed.....

Aesthetics

Discussion to be developed.....

Sand sources

Discussion to be developed....

§ 5 ENVIRONMENTAL IMPACTS

No federal action

Without the project, no impacts would occur except what would happen through normal erosional processes. At some time in the near future, erosion will eventually threaten the Great Highway and the municipal authorities will have to consider more draconian measures to protect their infrastructures.

Vegetation

Dune Nourishment: Small portions of the dune vegetation will be removed to permit trucking and grading of the sand. After construction, native species will be replanted on the new dunes and on the areas cleared for construction access. The negative impacts would be minor and temporary. Beneficial impacts are the creation of new areas of dune vegetation and some limited nourishment of the beach which may compensate for recession. Because this alternative requires periodic re-nourishment of the dunes, it will be a continuing impact. Monitoring and maintenance will be necessary to ensure successful re-vegetation.

Concrete Seawall: The dunes would be removed causing a permanent loss of vegetation in the study area. Mitigation would require a site suitable for construction of new dunes. Some of the sand removed during construction would be used for beach nourishment and building new dunes. Appropriate plantings and maintenance described above would stabilize the dunes. Assuming the siting and construction of new dunes does not cause new environmental considerations, the rebuilt and replanted dunes would offset the severe negative impact on vegetation, making that impact temporary. The beneficial impacts for this alternative are maximum protection to the Great Highway and sewer box and some recreational opportunity created by the promenade.

Fisheries

Dune Nourishment: There could be some slight increases in erosion during construction which may cause a slight temporary increase in turbidity and a decrease in water quality. This is not likely to have any significant effect on fishes or invertebrates.

Concrete Seawall: There could be some increases in erosion during construction which may cause an increase in turbidity and a decrease in water quality. This impact would be temporary and minor.

Wildlife

Dune Nourishment: Small portions of the dune habitat will be lost due to trucking and grading of the sand. Animals living in the dunes will be displaced by construction activity and noise. Some loss of wildlife may result from accident or burial. After construction, resident species will most likely re-colonize the area. Adverse effects are moderate and temporary. A beneficial impact is the creation of more wildlife habitat in the new and replanted dunes.

Concrete Seawall: The dunes would be removed causing a permanent loss of wildlife habitat in the construction area. Mitigation requirements would be similar to those for impacts on vegetation. Because the resident species would return, the rebuilt and replanted dunes offset the severe negative impact on wildlife making that impact temporary.

Water quality

Dune Nourishment: There could be some slight increases in erosion during construction which may cause an increase in turbidity and a decrease in water quality. This impact would be temporary and minor. However, pumping sand onto the beach in a slurry could cause some local, noticeable increases in turbidity.

Concrete Seawall: There could be some erosion during construction from fill stockpiles. This erosion has the potential to cause an increase in turbidity, but this effect should be insignificant. This impact would be temporary and moderate.

Noise

Since the construction equipment that would be used for either action alternative generates noise at levels comparable to the existing vehicular traffic on the Great Highway, there is no impact.

Hazardous, toxic, & radiological waste

No sites have been identified in the project area, however this needs to be confirmed.

Listed, proposed, candidate & other species

Dune Nourishment: Based on the habitat analysis performed by the U. S. fish and wildlife service, the rebuilt dunes are expected to produce approximately seven of new coastal dune habitat. This action exchanges flat sandy beach for sand dunes. Since the western snowy plover prefers flat, barren areas above the high tide line during the winter months, dune construction could displace the plover laterally along the beach until construction is completed. Post construction, when the dune faces are stable and flat areas are again in front of the dunes, plovers would likely continue to winter in front of the dunes. It is not clear at this time whether plovers nest at Ocean Beach. For the State listed bank swallow, Construction activity and noise near the Fort Funston Cliffs could have some effect on nesting activity.

Concrete Seawall: Because the seawall would be placed behind existing dunes or fill, wintering habitat for the snowy plover would not be lost. Construction activity could cause lateral displacement similar to the dune construction alternative. Construction activity and noise near the Fort Funston Cliffs could have some effect on nesting activity.

Cultural resources

There should be no impacts to Golden Gate Park, the San Francisco Zoo, the Cliff House from either of the action alternatives.

Marine archaeology

A site specific survey to determine the presence of marine artifacts buried at the project sites has yet to be accomplished. Until the survey results are known, the impacts are unknown.

Dune Nourishment: Because ....

Concrete Seawall: The impacts likely ....

Traffic

Dune Nourishment: The amount of sand required for this alternative is approximately 224,000 cubic yards. One hundred trucks transporting 2200 cubic yards per day, it will take approximately 100 working days to transport the requisite quantity of sand. Since the road system of San Francisco is well developed, and the project site is near major

commercial transportation routes, the traffic disruptions and delays are likely to be intermittent and minor. However, because the dunes will require re-nourishment every ten years, this impact will reoccur. Barging the sand to Ocean Beach would have no effect on traffic.

Concrete Seawall: There will be some slight increases in vehicular traffic along the Great Highway during the excavations for the seawalls. During construction, trucks will bring thousands of cubic yards of concrete increasing slightly the volume of vehicles using the Great Highway. This impact to traffic would be temporary and minor.

Air quality

When the probable construction and transportation scenarios have sufficient detail, and emissions inventory for the proposed project will be calculated and evaluated for compliance to the Clean Air Act.

Trucking in sand for dune creation or excavation for the seawalls would generate more fugitive dust than the barge transportation of sand.

Recreation

Dune Nourishment: Initially, the loss of use of several thousand square feet of beach will have an adverse impact on beach users. However, the beach area available for recreation often varies widely from natural causes and the areas designated for dune building are not large relative to the whole beach. The dunes are, in part, sacrificial and some of this sand serves to nourish the beach. Some beach users appreciate the dunes and may perceive dune building as positive. Overall, dune building may have a neutral impact on recreation.

Concrete Seawall: A small portion of the dune system will be replaced with a pedestrian promenade which will alter the accessibility of the beach and which may cause a shift in recreational uses for the affected reaches.

Aesthetics

There could be some slight increases in erosion during construction which may cause an increase in turbidity and a decrease in water quality. Earthmoving equipment on the beach will affect the visual appeal of the beach. This impact would be temporary and

minor for either action alternative and would re-occur periodically with the dune nourishment alternative.

Concrete Seawall: Because the seawalls are designed as visible structures, the natural aesthetics of the beach will be permanently reduced to some extent. More lineal feet of seawall may enhance beach access or panoramic appreciation and to some extent, this may be perceived as a positive impact. The seawall does little to prevent blowing sand.

Dune Nourishment: Dune vegetation limits blowing sand. Dune nourishment has the potential to improve the aesthetic appeal of Ocean Beach. Fencing or boardwalks are necessary to protect vegetation on the new dunes. Once dunes and vegetation are established, interpretive signage would make the public aware of native vegetation.

Sand sources

Sand mining on or around the San Francisco Bar to provide sand for the dune nourishment alternative may require environmental assessments or impact statements if existing commercial sources cannot meet the demand.

§ 6 MITIGATION

Incremental analysis

Dune Nourishment: The U.S. Fish and Wildlife Service is of the opinion that the dune nourishment project is self mitigating. Because the habitat value of the existing dunes is low and the dune nourishment alternative creates habitat that is scarce along the California coast, the Service did not do a standard Habitat Evaluation Procedure, but instead calculated a habitat based evaluation and concluded that nine acres of dune habitat would be created from this alternative. Requested mitigation is only for construction related impacts.

Seawall: In the request for the preliminary Draft Coordination Act report, the seawall was not an alternative. If the seawall is carried further through evaluation, a habitat analysis would have to done prior to the delivery of the next Coordination Act Report. The seawall alternative has potential to create three acres of dunes at Ocean Beach.

Vegetation

Dune nourishment:

Seawall:

Fisheries

Dune Nourishment: If sand is trucked in and placed dry, erosion from the dry beach into the ocean is expected to be 2% or less of the littoral sand budget at Ocean Beach and should not be detectable. No mitigation is planned for this construction method. If the sand is transported by barge and the sand pumped ashore in a slurry, runoff and erosion control measures would be necessary to keep sand on the beach.

Seawall: The seawall and its construction would have no impact to fisheries and therefore would not require any mitigation.

Wildlife

Dune Nourishment: The initial layer of sand deposited on the beach would be limited to a depth of one foot to permit the escape of beach-dwelling wildlife. Since habitat is being created with this alternative, no further mitigation is necessary for this habitat type.

Seawall: With this alternative, an area equal to the size of the seawall and construction access area would be lost to wildlife during construction. Post construction, surplus sand from the seawall excavation could be used to create new dunes to compensate for the habitat lost to the seawall.

Water quality

Dune nourishment:

Seawall:

Hazardous, toxic, & radiological waste

No mitigation is required until these types of materials are determined to be present in the project area.

Listed, proposed, candidate, & other species

For the State listed bank swallow, construction activity would not take place near the Fort Funston cliffs during their nesting season; roughly from the beginning of April to the end of June. In the case of the snowy plover, construction would be avoided during the winter months when plovers are at the beach. If plovers are nesting during the summer, a strategy to avoid impacts would have to be developed in cooperation with the Fish and Wildlife Service and the National Park Service.

For the other 28 species of concern, their occurrence at Ocean Beach is not likely and no mitigation for these plants and animals is necessary.

Cultural resources

No cultural resources exist in the APE, therefore no mitigation is required.

Marine archaeology

At this time, the presence or absence of archaeological resources buried at Ocean Beach in the project reaches is not well known. Mitigation for these resources, if necessary, will have to be developed after the survey results are published.

Social environment

The need for mitigation would have to be considered in light of the results of the survey.

Traffic

Dune Nourishment: depends on construction and transportation scenario....

Seawall: depends on construction and transportation scenario....

Air quality

Discussion needs to be developed....

Recreation

Dune Nourishment: The impact to recreation for this alternative would be mitigated by nourishing one reach at a time. Since the erosion of sand from the beach is expected to be not more than 2% per year, the impact to surfing should be insignificant.

Seawall: By constructing one seawall at a time, the maximum possible pedestrian access would be maintained along the Great Highway.

Aesthetics

Discussion needs to be developed.....

Sand sources

Three probable sand sources have been identified. These are all existing commercial operations and no mitigation should be necessary.

§ 7 RESPONSES TO USFWS RECOMMENDATIONS

The US Fish and Wildlife Service furnished the Corps a preliminary draft Fish and Wildlife Coordination Act Report for this project in September, 1993.

General mitigation aspects

☼ To minimize the adverse effects of sand dune nourishment on terrestrial species, sand placement should be done on a gradual, intermittent basis that allows optimal escape, relocation, and thus survival of sand-dwelling organisms. Very rapid and deep placements of large quantities of sand should generally be avoided. We recommend that not more than 12 inches vertical depth of sand be initially placed for the first twenty-four hour period.

> ***Response:*** *The Corps realizes that sand dwelling invertebrates would be needlessly eliminated from the beach if the nourishment sand is piled too deeply for them to escape and will specify in the contract for construction a 12-inch depth limit for the initial deposition of sand.*

☼ Also, sand grain size should be adequate to minimize erosion, while at the same time provide a substrate suitable for sand dwelling organisms.

> ***Response:*** *The Corps is studying grain size and will match as closely as practicable the grain size presently at Ocean Beach.*

☼ The source of sand for the nourishment should be from an approved borrow source, and be free of any contaminants, either physical or chemical, that could affect benthic organisms in the beach areas.

> ***Response:*** *The Corps intends to obtain clean sand for this project from an existing, permitted sand supplier. The Corps will not accept* ***any*** *contaminated sand for this project.*

☼ Also, the use of sand from a source which presently provides nesting or foraging habitat for significant fish and wildlife species (for example, bank swallows) should be avoided.

Response: Again, the Corps plans to obtain sand from a reputable supplier who will obtain sand from existing, permitted sources.

☼ Additionally, beach nourishment should be accomplished when sensitive species are not in the area. Construction activities should generally be limited to late April through early July for Reaches 1 and 2, and September through March for Reach 3 because wintering plovers are known to occupy Reaches 1 and 2 in the winter, and bank swallows are nesting and active in Reach 3 in the spring and summer.

Response: *The Corps will utilize the construction windows specified by the US Fish and Wildlife Service and the California Department of Fish and Game to avoid any impact to the western snowy plover and the bank swallow.*

☼ Planting of non-native grasses should be avoided as that has been shown to eliminate native terrestrial invertebrates and other wildlife species that depend on them for sustenance.

Response: *The Corps' re-vegetation plan will utilize, where feasible, native species indigenous to Ocean Beach or to the central coast dune community.*

☼ Any vegetation which is disturbed by sand placement activities should be restored to native sand dune habitat.

Response: *The Corps routinely landscapes and re-vegetates for erosion control after construction and will plant dune species, where feasible, in those areas disturbed by construction activity.*

☼ Adverse impacts to aquatic organisms should be avoided to the extent practicable. Much of the direct impact to the aquatic community could be reduced by the use of dredge material from a previously or ongoing project, rather than a new dredging effort implemented for this project.

Response: *The Corps does not plan new dredging to supply sand for the project. There are numerous on going dredging projects in the San Francisco Bay and delta, however, roughly 90% of this material is mud.*

☼ Initial and maintenance dredging should be timed to avoid the period of peak organism use, particularly by fish and invertebrates. In general, impacts to these species can often be minimized by restricting work to the late summer and early fall months (late August to early November).

> ***Response:*** *The Corps does not plan to dredge sand for the project. However, if dredging is necessary the Corps will utilize the construction windows specified by the US Fish and Wildlife Service and the California Department of Fish and Game to minimize any impact to marine resources.*

Specific mitigation aspects

We recommend that the following actions be implemented as part of the project at Ocean Beach. These general guidelines closely follow those implemented for the Asilomar Dunes Restoration Project at Asilomar State Beach. The Asilomar Project is one of the more successful, long-term dune restoration projects on the West Coast.

☼ A contractor that specializes in propagation and restoration of native sand dune plant species should be consulted prior to the implementation of the final plan.

> ***Response:*** *The Corps plans to consult with potential contractors before finalizing the re-vegetation plan. In addition, the Corps has already consulted with key personnel at Asilomar, Marina State Beach, Lamphere Dunes State Reserve, and others active in dune restorations on the west coast.*

☼ All restoration work should be coordinated with the National Park Service.

> ***Response:*** *The dune project is sited on Park Service land. Coordination with Park Service planners began in the reconnaissance phase of study and will continue for the life of the project.*

☼ Seed collection. To help preserve and restore the genetic integrity of the local plant community, native plant seeds should be collected in the vicinity of the project area. Because of the low numbers of native species in the area, caution should be used to ensure that the seed source for the area is not depleted below a self-sustainable level. If this were the case, seed should be obtained from a local nursery that specializes in the propagation of native plants.

Response: *The Corps plans to contract with the Park Service or a commercial vendor for container plants for the project. Seed collection at Ocean Beach is regulated by the Park Service.*

☼ Management of exotic species. European beach grass is abundant on the existing dunes at Ocean Beach. This species is highly aggressive, and tends to compete with native species. Although eradication of this species from the project area is not part of the proposed project, management will be necessary to ensure that this species does not invade into the restoration area and compete with native plantings. The most effective methods of management appear to be manual removal and herbicide treatment. Manual removal is preferred; if herbicides are used, caution must be used to avoid spraying native plants and particularly, sensitive species.

Response: *Control of European beach grass, if necessary, will be done by manual methods.*

☼ Dune reconstruction and stabilization. According to project information, sand would be brought onto the construction site by slurry pipe or truck. In either case, dunes would be built from the existing dunes seaward using earth-moving equipment. Since young plantings would have a difficult time surviving on an active dune, the sand will need interim stabilization while planted seeds or plants are becoming established. It is recommended that some type of matting be used to prevent sand erosion, particularly by wind, until plants become established. We recommend either of two methods: hydromulching or planting straw clumps into the sand. Both methods have been found to be successful. A minimum of 2 years stabilization is usually needed.

Response: *At this time, straw clumps could be the favored stabilizing planting technique, because this method is more compatible with planting container stock.*

☼ The use of soil-seal, an artificial sealant, is not recommended as it has been found to repel water and inhibit plant growth at the Asilomar dune restoration site.

Response: *The use of this type of agent is probably not consistent with the management strategy of the Park Service at Ocean Beach; the Corps does not intend to use this technique.*

☼ Re-vegetation: Species composition should consist of species native to the area, that presently occur or historically occurred on the site. Locally collected seeds should be propagated near the project site and the resulting container plants used in the re-vegetation effort. We recommend using container plants rather than seed because of the highly unstable conditions at the site. Use of seeds would likely result in a significant reduction in plant establishment and survival. Seeds would likely be transported by wind and covered by blowing sand. Plantings would be better suited to surviving these harsher conditions.

> ***Response:*** *Regardless of the environmentally challenging conditions at Ocean Beach, the Corps intends to use plantings from container stock because stabilizing vegetation is established sooner by this method.*

☼ Irrigation should be used, but in a way that ensures plantings do not become dependent on it. If not done carefully, irrigation could produce weed plants and cause plants not to establish an adequate root system.

> ***Response:*** *The primary project purpose at Ocean Beach is storm protection via sacrificial dunes. Irrigation, if used, will be very limited.*

☼ Measures should be taken to provide protection to the restoration area. These measures should include fencing and boardwalks to guide pedestrians away from the restored area, and educational signs posted to inform the public about the significance of the areas and the importance of protection. Similar work has been done by the National Park Service at Baker Beach and could be used as a model for the Ocean Beach project.

> ***Response:*** *The Corps has investigated several dune restoration projects along the California coast, including the Baker Beach restoration. All successful dune restoration projects employ some form of fencing, controlled pedestrian traffic and appropriate signage. Further, the Corps will use methods that are compatible with Park Service policy and techniques.*

Specific mitigation recommendations

☼ The final report of the Corps of Engineers include conservation and enhancement of fish and wildlife resources among the project purposes for which this project is to be authorized.

Response: . . .

can we draft this language or are we limited by the study authorities?

☼ The Corps complete, forthwith, its Section 7 requirements under the Act, so that the results of such may be effectively integrated into the Service's recommendations and final FWCA Report for the project.

Response: *The Corps is aware of its responsibilities under the Endangered Species Act and will comply with this request.*

☼ The local sponsor of the project complete, forthwith, any consultation requirements with the California Department of Fish and Game required under the California Endangered Species Act relating to the State-listed threatened bank swallow, so that the results of such may be included in the Service's final FWCA Report.

Response: . . . .

☼ To minimize adverse impacts to aquatic organisms, previously dredged material or an existing borrow site be used for sand dune nourishment, rather that initiating new dredging for this project. In either case, only sand of the proper size, consistency, and quality should be used.

Response: *The Corps intends to use clean sand of the appropriate grain size from an existing, permitted sand supplier.*

☼ All phases of the vegetative restoration program be coordinated with the National Park Service staff biologists to ensure that plantings are consistent with their biological objectives for Ocean Beach.

Response: *The dune project is sited on Park Service land. Coordination with Park Service planners began in the reconnaissance phase of study and will continue for the life of the project.*

☼ *Created dunes be properly fenced to prevent foot traffic from entering the restoration sites.*

> ***Response:*** *Fencing will be a component of the restoration plan. However, due to the limited beach berm in certain areas, vegetation or fencing may not be placed for some years until new dunes are at least semi-stabile.*

☼ Also, interpretive signs signifying dune restoration should be erected within the fenced area.

> ***Response:*** *Signage will be a component of the restoration plan.*

☼ Boardwalks be constructed between dunes to minimize traffic through the dune restoration area.

> ***Response:*** *Boardwalks or some form of pedestrian traffic control will be a component of the restoration plan.*

☼ The Corps develop a detailed re-vegetation and remedial action plan for the project. The plan should be developed by an independent contractor familiar with native plant restoration, with input from the National Park Service, California Department of Fish and Game, California Native Plant Society, and the Service. Vegetative monitoring should be conducted during the first 10-year period, and subsequent periods, if needed.

> ***Response:*** *The Corps will develop, or have developed, a vegetation monitoring plan for the life of the project. Input from the resource agencies, conservation groups, contractors and the public will be considered in the development of the plan.*

☼ *During construction, construction areas be fenced or otherwise marked to exclude construction vehicles from encroaching into the intertidal zone.*

> ***Response:*** *The Corps will specify this in the construction contract.*

☼ The proposed construction schedule, during which sand would actually be deposited on the beach, be restricted to late April through early July for Reaches 1 and 2, and September through March for Reach 3 to avoid impacts to sensitive species. Both initial sand placement and maintenance placement should be carried out during these periods.

> ***Response:*** *The Corps will utilize the construction windows specified by the US Fish and Wildlife Service and the California Department of Fish and Game to avoid any impact to the western snowy plover and the bank swallow.*

☼ Sand be placed on the beach in small increments, as described earlier in this report, to minimize adverse impacts to beach fauna.

> ***Response:*** *The Corps realizes that sand dwelling invertebrates would be needlessly eliminated from the beach if the nourishment sand is piled too deeply for them to escape and will specify in the contract for construction a 12-inch depth limit for the initial deposition of sand.*

§ 8 RESPONSES TO PUBLIC COMMENTS

AGENCY & COMMUNITY CONCERNS & COMMENTS

Public Meeting 10 December 1992

☼ How will each of the project alternatives contribute to the maintenance of a sandy, recreational beach?

Response: *The no action alternative will not contribute to the maintenance of a recreational beach.*

The seawall protects the land behind it and allows for a sandy beach in front of it. During periods of erosion, the sandy beach in front of the seawall may be lost, however, erosion is halted at the seawall and during accretionary periods, the sandy beach may return.

Dune restoration places sand on the beach and stabilizes the sand with vegetation. Dune plants are adapted to salt water and windy conditions and hold the sand in place with their root systems. The stems and leaves of dune plants limit the eolian movement of sand.

When the dunes are eroded, most of the sand pulled offshore will stay in the offshore berm and will be available to rebuild the beach berm during the summer when accretionary waves prevail.

☼ Placement of the sand on the dunes should be analyzed for its potential contribution to the littoral system as a whole and to the long term continuation of the recreational beach.

Response: *Longshore and on-offshore sand movement is being studied by the Corps prior to selecting sand replenishment as a viable alternative.*

☼ Will the sand used to nourish the dunes be physically suitable for the recreational beach as well?

Response: *Yes. The silt content will be limited to 3%*

☼ What effect will the project have on lateral access to the beach?

Response: *Lateral access to the beach will be restricted over a 300-foot length of beach during sand placement. Frontal access will be restricted for a variable distance equal to the width of the new dune sand and the area needed for the operation of the equipment needed to place and shape the sand.*

☼ What will be the impacts to the aesthetic value of the dunes and beach?

Response: *During construction the dunes and beach will lose some aesthetic appeal. However, once the dunes have been shaped and vegetated, the visual appearance will be better that it is now and they will likely attract more wildlife than at present.*

☼ What will be the impacts to the visitor experience at Ocean Beach?

Response: *In the short term, beach visitors will experience restricted use of the beach on the project reaches and a less than appealing panorama. Some may find this a pleasing sight because it is tangible evidence of public agencies doing something to address the problem of beach erosion. In the long term, some parts of the presently flat beach will be converted to dunes. The sand in front of the dunes will be re-distributed by natural processes and some of the beach will re-establish itself. The recreational beach may be slightly smaller, but the reduction of eolian erosion and the dune vegetation should retain sand and contribute to a more attractive dune setting.*

☼ What are the impacts to public safety from this project?

Response: *The City of San Francisco's Clean Water Project is intended to reduce the instances and volumes of untreated waste water into the Ocean. Since the Westside Sewer transport box is under the Great Highway, protecting the Great Highway from wave damage and reducing blowing sand make the sewer box more secure and travel along the Great Highway safer. To maintain the safety of visitors on the beach temporary fencing may be necessary to separate beach users from construction equipment. From a traffic safety standpoint, trucking sand along the Great Highway will generate an insignificant increase in the number of vehicles.*

☼ How will this project affect dune and beach ecosystems?

Dune building and plantings will restore some of the dune ecosystem that once existed at Ocean Beach. The addition of sand to the recreational beach will eliminate or bury the resident invertebrates, but these animals will re-populate the sand when construction is complete. The sand added to the littoral system is expected to be added to the system by natural wave action and should not have any measurable effect on the intertidal community.

☼ How will this project affect benthic habitat offshore of the project?

Response: *Sand from the dune restoration may, through natural processes, be transported into the intertidal zone. The rate of transport is expected to be very slow and insignificant in volume compared to the sand movement along Ocean Beach.*

☼ What will be the impacts to cultural resources in the area?

The cultural resources at Ocean Beach are the historic district at Seal Rock composed of the Cliff House, Sutro Heights, and the ruins of the Sutro Baths, Golden Gate Park, and the San Francisco Zoo. All of these resources are some distance from the proposed dune restoration sites and the project should have no effect on these resources.

☼ What are the impacts to shipwrecks buried in the beach and surf zone?

Response: *For those shipwrecks in the surf zone there should be no impact as sand will not be placed seaward of the high tide line. For shipwrecks buried in the beach, there is no planned excavation into the beach, so these will remain buried. Consultation with the National Park Service has been initiated to ascertain the presence of shipwrecks in the project area. If it appears that such artifacts are in jeopardy from the dune project, protection for these items will be developed in cooperation with the National Park Service and the State Historic Preservation Office.*

☼ What will the short term construction impacts be?

Response: *The short term impacts will be degradation of the scenic appeal of the beach area, minor increases in noise, dust, and vehicle emissions, and loss of the use of approximately seven acres of flat recreational beach.*

☼ What are the long term construction impacts?

Response: Some flat part of the beach will be converted to sand dune causing the loss of use of that part of the beach. Periodic re-nourishment may be necessary and the short term construction impacts will re-occur.

☼ What are the effects to traffic flow and access to the parking lots?

Response: *If sand is trucked to the beach, the existing haul road at the south parking lot will be used. There are no plans to close this parking lot so access will not be denied, but some minor traffic delays may result from dump trucks transiting the parking lot.*

☼ Will this project be consistent with the GGNRA General Management Plan?

Response: *Yes, because the dunes are not a "hard" engineered structure, the proposed project is consistent with the Park Service's management goal of preserving the natural appearance of Ocean Beach. Further, the dune project creates a wildlife habitat that is dwindling in California.*

☼ Will this project comply with Executive Order 11987 which prohibits the introduction of non-native plants in Federally funded projects?

Response: *Yes, the Corps' plan will utilize, where feasible, native species indigenous to Ocean Beach or the central coast dune community.*

☼ Will this project comply with AB 1108 which extends the Noxious Weed category to plants which threaten native plants?

Response: *This Assembly Bill became law on August 27, 1992. The Bill amended two sections of the State Food and Agriculture Code. The Director of Food*

and Agriculture, after investigation or survey, may consult with other state and federal agencies and proclaim an area to be practically weed free. Once an area is proclaimed as such, it is unlawful to transport the seed of any noxious weed into the area. Since the habitat at Ocean Beach is predominately weedy species, it does not seem probable that the dunes at Ocean Beach would qualify for proclamation. The point is moot however, as the Corps intends to vegetate with native species consistent with restoration plantings in dune environments with the GGNRA.

☼ Will the sand samples used for comparison be those from twenty years ago or from today? Past nourishments imported sand from Monterey.

Response: *Beach sand samples used for comparison with sand sources will be modern day.*

☼ Will this project improve or detract from the ocean view?

Response: *Since native dune plant species tend to create low, gently sloping dunes, the high crowned dunes found elsewhere at Ocean Beach will not be developed and the view should not be affected.*

☼ How will impacts to the potentially threatened western snowy plover, which winters from mid-November to March on the dunes between Noriega Street and Lincoln Way and from Sloat Boulevard and Santiago Street, be avoided?

Response: *Construction will not take place during the winter, or near the plovers if they are frequenting the beach.*

☼ *How will impacts to the state endangered bank swallow, which nests in the Fort Funston Cliffs from April to August, be avoided?*

Response: *Dune construction will not be done close to The Fort Funston cliffs while the bank swallows are nesting.*

☼ We would like to see a long term wildlife monitoring plan for the area.

Response: *The National Park Service monitors wildlife at Ocean Beach.*

☼ We would like a mitigation plan for the project impacts.

Response: *The Corps always develops mitigation plans for projects. The Mitigation plan for this project is presented in detail in another section of this document.*

☼ What about sand quality and its affect on reducing eolian transport?

Response: *The sand will be good quality beach sand, a bit coarser than the existing dune sand and therefore, less susceptible to eolian transport.*

☼ What affect will this project have on the beach breaks and how will this impact be mitigated?

Response: *Because the sand will be placed on the dry beach, there should be no effect the beach breaks.*

☼ What will be done about toxic substances in the sand used to nourish the dunes?

The Corps will not accept ***any*** *contaminated sand from a contractor.*

☼ What will be done about the cleanliness of the sand and runoff of silt into the ocean?

Response: *Only clean sand (≤3% silt permitted) will be accepted for this project.*

☼ What are the effects of drought conditions on natural sand replenishment at Ocean Beach?

Response: *Rainfall and subsequent runoff contribute to the erosion of rock into sand and the transport of this sand via rivers to the ocean where it enters the littoral system. Rainfall also contributes to the erosion of sea cliffs depositing sand directly onto beaches. Ignoring the other influences on sand supply, less rain means less erosion and lower transport rates and less sand available to the beaches.*

☼ At one time, a seawall was considered to be the only solution to erosion at Ocean Beach and that sand replacement would not work. The City board of supervisors passed a resolution for seawall construction. Why is dune nourishment now a workable alternative?

Response: *At this time, dune nourishment is proving to be the most economical solution.*

☼ What will be the effects of sand replenishment on feeding shorebirds?

Response: *Shorebirds usually feed on the ebbing tide in the zone of wet sand behind the receding wave. The project does not place sand in this zone so there will be no direct effect to feeding shorebirds. Sand will likely be added to the swash zone through the daily and annual movement of sand by natural processes, but at a rate slow enough to have insignificant impact.*

☼ What will be the effects of sand replenishment on marine fisheries?

Response: *Somewhat less than those effects to feeding shorebirds.*

☼ Dune vegetation should be evaluated as an engineered part of the dune system and not just a wildlife amenity.

Response: *The intent of the Corps from the inception of the project has been to make use of dune vegetation to stabilize sand. The use of dune plants for this purpose is currently under study.*

☼ The use of non-indigenous materials for the dune core should be evaluated.

Response: *Non-indigenous materials have been used for dune cores for other dune projects. If such material were to be used at Ocean Beach and storm action exposed the core, the Corps would be responsible for placing structures or materials on the beach which are inconsistent with the GGNRA management plan.*

☼ The dunes should be designed to be self-maintaining.

Response: *The inclusion of native dune community species as a project element is intended to make the dunes self maintaining. Once the dune vegetation has been established, subsequent nourishments should require less sand. It should be remembered, however, that the dune as intended to be somewhat sacrificial and as such, they may never be completely self-sustaining.*

☼ What will be the effects of the project on housing development in the area?

Response: *Since the area has already been developed there should be no effect from the project.*

☼ Why do you feel that the sand will not build up in front of the new seawall as it did in front of the O'Shaughnessy wall?

Response: *Wave action has a different effects on sand deposition at various locations along the beach.*

☼ What will be done about people trampling the dune vegetation?

Response: *Fencing will be installed to limit foot traffic through planted areas. Signs will be posted to inform beach users and to elicit their cooperation in minimizing damage to the dune plants.*

☼ What will be the effects of this project on recreation as a result of an altered sand budget for the offshore bar?

Response: *Some of the sand placed on the beach above the high tide line may eventually become part of the littoral transport system of Ocean Beach. However, the quantities of sand added to the beach are 10% of the sand volume in littoral transport at Ocean Beach. Re-nourishments are expected to occur at five year intervals, This is a 2% annual increase in the sand budget of the littoral cell and should not be detectable.*

☼ The EIS should describe how all project activities relate to The Bay Area Conservation and Development Commission's mandate and authority, and to the Federally approved Coastal Management Plan.

Response: *The Bay Conservation and Development Commission does not have jurisdiction over Ocean Beach. The Corps did however, invite their participation in the scoping process, and their comments on the project will be discussed in the EIS.*

The dune nourishment alternative is consistent with the local coastal plan because of the use of a "soft" engineering structure and because the project adds sand to the system.

☼ What about the dredging impacts at Point Knox Shoal?

At this time, it is not confirmed that sand will be extracted from Point Knox Shoal.

☼ The Bay Plan allows authorization of only necessary dredging projects. Discuss the need to dredge relative to Ocean Beach.

Response: *The Corps intends to use existing commercial sources of sand. There is no specific need to develop a new source of sand to be dredged from the Bay for this project.*

☼ *Evaluate alternative sand sources.*

Response: *We are in the process of evaluating alternative sand sources.*

☼ Why can't the 900,000 cubic yards taken from the San Francisco Bar ship channel be used?

Response: *The sand in the ship channel is not of the appropriate grain size for Ocean Beach.*

☼ Discuss the project in terms of Bay Plan Amendment 3-91

Response: Amendment 3-91 addresses dredging and disposal of dredged material in San Francisco Bay. The Corps does not intend to cause new dredging in the Bay. If sand from the Bay is utilized, it will come from an existing, permitted, commercial source. If sand is removed from the Bay, its placement on Ocean Beach is beyond BCDC jurisdiction, therefore, the recommended policies for disposal are not applicable to the project.

☼ How will this project avoid impacts to the sea water intake for the Steinhart Aquarium located near Golden Gate Park?

Sand will not be placed anywhere near the intake, therefore, the project will have no impact on the Steinhart Aquarium.

☼ *European beach grass should be replaced with native plants and an attempt made to expand the population of beach pea* ***Lathyrus littoralis.***

Response: *The project does not specifically replace European beach grass, but the dune vegetation plan will be done with native dune species, as practicable, and may include the beach pea.*

☼ Dune retreat may have been arrested by recent stabilization efforts. Is this project really necessary?

Response: *Dune retreat may be arrested elsewhere along Ocean Beach, but surveys show that the dunes in the project reach could use some help.*

☼ Document some successes where this kind of solution has worked over a twenty year period.

Response: *A brief study of dune projects was contracted. The study report on nine successful dune restoration projects. Monitoring periods were from three to 30 years. Vegetated dunes survived better during storm event and performed better at holding sand than un-vegetated dunes.*

☼ Document two failures where this type of solution was predicted to succeed and failed.

__Response:__ Spanish Landing in Monterey County - the sand used was too coarse to allow the proper establishment of dune vegetation. Also, golf courses contiguous to dunes result in excessive trampling and sand disturbance.

At Hunting Island State Park, South carolina, a massive beach nourishment project was only partially successful. Excessive longshore transport was determined to be the cause.

☼ *I'm sorry to differ with the Sierra Club, but its a matter of priority. We may need this particular (European dune grass) plant.*

__Response:__ The efficacy of European dune grass __Amophilla arenaria__, is well known. There are other plants, i.e. the species that formerly covered the dunes of San Francisco, that are capable of living in the beach environment and that can control drifting sand.

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§ 10 COMPLIANCE WITH ENVIRONMENTAL LAWS & REGULATIONS

Archaeological & Historic Preservation Act of 1974, 16 USC 469a, *et seq.*

This Act directs the preservation of historic and archaeologic data that would otherwise be lost as a result of Federally authorized activities. This project may generate some of this type of information; this Act is could be applicable to the proposed project.

Clean Air Act of 1972, as amended, 42 USC 7401, *et seq.*

Section 176 of this Act prohibits Federal action or support of activities which do not conform to a State Implementation Plan. The Corps will compile and emissions inventory for the preferred alternative. If the annual inventory exceeds the *de minimis* levels prescribed by the 1994 amendments, changes to the construction scenario would be considered to bring the proposed project into compliance with this Act.

Clean Water Act of 1972, as amended, 33 USC 1251, *et seq.*

The placement of sand above the high tide line would not directly affect the waters of the United States. However, if sand for dune nourishment is pumped onto the beach, measures to control runoff induced turbidity would be necessary to ensure compliance with this Act.

Coastal Zone Management Act of 1972 16 USC 1451 *et seq.*

Work under the construction alternatives would directly affect the coastal zone of the State of California. Under Section 307(c) of the Coastal Zone Management Act, the proposed construction must be consistent to the maximum extent practicable with the State's approved management program, i.e. the California Coastal Plan. In addition, Federal agencies must submit a consistency determination to the relevant State agency as soon as practicable. A draft consistency determination will be submitted to the California Coastal Commission prior to submission of the draft Feasibility Report.

Endangered Species Act of 1973, as amended, 16 USC 1531, *et seq.*

In accordance with Section 7(c), coordination with the U.S. Fish and Wildlife Service is being conducted and it has been determined that the western snowy plover winters at Ocean Beach and could likely to be affected by this project. Possible effects and their avoidance, to this species will be discussed in a biological assessment and coordinated with the U.S. Fish and Wildlife Service. If necessary, preventive or corrective measures will be taken to safeguard this species. Further coordination and consultation will be undertaken as necessary to ensure the proposed project is in compliance with this Act.

Estuary Protection Act of 1965, 16 USC 1221, *et seq.*

This law requires the consideration of estuaries and their natural resources by Federal agencies for all project plans affecting them. Projects must consider, in a comprehensive manner, the conservation and protection of such resources and be in compliance with other statutes protecting estuarine resources. The proposed project has no effect on any estuary; this Act is not applicable to the proposed project.

Federal Water Project Recreation Act of 1956, as amended, 16 USC 460 l-5, to l-12, *et seq.*

The proposed project provides some recreational amenities as functional project features. Therefore, it is in compliance with this Act.

Fish and Wildlife Coordination Act of 1958, as amended, 16 USC 661, *et seq.*

Formal coordination with the U.S. Fish and Wildlife Service began with a request for an updated species list. A preliminary draft Fish and Wildlife Coordination Act Report was furnished in March of 1993. Because of changes in listing status of some species, another species list was obtained in March 1994.

Land and Water Conservation Fund Act of 1965, 16 USC 460 l-4 to l-11, *et seq.*

This act is included in the Federal Water Project Recreation Act.

National Environmental Policy Act of 1969, as amended, 42 USC 4321, *et seq.*

The scoping process, EIS/R, coordination, report circulation, review process, and consideration of comments, provide compliance with this Act.

National Historic Preservation Act of 1966, as amended, 16 USC 470

In accordance with 36 CFR 800, the implementing regulations for § 106 of the Act, the Corps delineated the Area of Potential Effect (APE) and consulted with the State Historic Preservation Officer to identify historic properties that may be affected by the proposed flood control project. There are no historic properties within the APE. Therefore, the Corps is not required to take further steps in the § 106 consultation process; this project is in compliance with the Act.

Rivers and Harbors Act of 1899, 33 USC 403, *et seq.*

Because the proposed project does not affect a navigable waterway, this Act is not applicable to this project.

Watershed Protection and Flood Control Act of 1954, 16 USC 1001, *et seq.*

The proposed project is not on or near a floodplain, so this law is not applicable.

Wild and Scenic Rivers Act of 1968, as amended, 16 USC 1271, *et seq.*

In all planning for the use and development of water and land related resources, Federal agencies shall give consideration to potential national wild, scenic, and recreational river areas, and in all river basin and project plans submitted to the Congress shall consider and discuss such potential designations. This Act is not applicable, because the proposed project is not in a riverine setting.

Executive Order 11987, Exotic Organisms, May 24, 1977

Section 2. (a) requires executive agencies to restrict, to the extent permitted by law, the introduction of exotic specie into natural ecosystems under that agency's control.

Because the Corps plans to vegetate dunes with native species compatible with existing restoration efforts at Ocean Beach, the proposed project complies with this Order.

Executive Order 11988, Floodplain Management, May 24, 1977

In accordance with this Order, the proposed actions should serve to minimize the impact of floods on human safety, health, and welfare. Because the proposed project is not on or near a flood plain, this Order is not applicable.

§ 11 LISTED, PROPOSED, CANDIDATE, & OTHER SPECIES

Listed species

The Sacramento River winter-run Chinook salmon *Oncorhynchus tshawytscha* is a unique population that is distinguishable from other Chinook salmon runs in the Sacramento River based on the timing of its upstream migration and spawning period. For the most part, the winter-run chinook salmon population is comprised of three year classes, each of which primarily returns to spawn as 3-year old fish. The construction of the Friant Dam on the San Joaquin River in 1945 curtailed access to the spawning grounds of that drainage, eliminating that portion of the run. The Shasta Dam, constructed in 1942, closed off the upper spawning areas in the Sacramento River. The Red Bluff Diversion Dam went on line in 1967 restricting spawning fish to a roughly 50-mile section of the River below Keswick Dam. Drought conditions, and loss of riparian shade, which promote elevated water temperatures, also contribute to poor reproductive success.

In 1989, the CDFG estimated that the winter-run Chinook salmon run size was only 547 fish. This unexpectedly small return represented nearly a 75 percent decline from the consistent, but low, run size of 2,000 to 3,000 fish that had occurred since 1982. As a result of this unexpected decline, NMFS issued an emergency interim rule listing the winter-run as threatened August 4, 1989 (54 FR 32085). During the period the emergency interim rule was in effect, NMFS published a proposed rule to list winter-run Chinook salmon as threatened under formal listing procedures on March 20, 1990 (55 FR 10260). Federal protection was extended with a second emergency interim rule listing winter-run chinook salmon as threatened on April 2, 1990 (55 FR 12191). On November 5, 1990, NMFS completed the formal listing process and published a final rule (55 FR 46515) listing the species as threatened. On June 5, 1991, the American Fisheries Society petitioned NMFS to reclassify winter-run Chinook salmon as an endangered species. At that time, the best preliminary data available indicated that the 1991 run would consist of a return of only 88 to 200 adults from the progeny of the 1988 run of 2,085 fish. The final run size estimate made by the CDFG for 1991 was 191 fish. Subsequently, NMFS reviewed the petition and determined that the petitioned action might be warranted. On November 7, 1991 (56 FR 58986), NMFS announced its intention to review the status of the species. On June 19, 1992 (57 FR 27416), NMFS published a proposed rule to reclassify winter-run chinook salmon as endangered. Later, NMFS published a notice on June 4, 1993 (58 FR 31688) delaying a final determination for up to six months pursuant to section 4(b)(6)(B) of the ESA. On September 10, 1993, NMFS published another notice (xx FR xxxx) that provided information on the 1993 run size estimate (341 fish) and reopened the public comment period on the proposed rule. On January 4,1994 (59 FR 440) the final rule making reclassified the winter-run as endangered.

Sport fishing for Chinook salmon is common offshore at the approaches to the Golden Gate from spring to fall. Since salmon are not normally found in the surf zone, and the fishing areas thèy are commonly found in areas a couple of miles away from the proposed construction sites, there should be no impact from either construction alternative.

The **tidewater goby *Eucyclogobius newberryi*** was first described in 1856 from specimens taken in the San Francisco Bay area. It is a small fish that inhabits coastal lagoons and bays from Del Norte County in northern California to San Diego County in southern California. Tidewater gobies are unique because they apparently lack a true marine phase in their life history. This apparent absence of a marine phase or, affinity for very low salinity water, may account for their discontinuous distribution along the California coast. While historical local extinctions from high flows of storm water may have reduced populations of tidewater gobies in the past, loss of habitat from stream channelization, ground water pumping which permits saltwater intrusion, and siltation from poor land management practices are modern threats to this fish. The tide water goby was listed endangered February 4, 1993 (59 FR 5494). There is no suitable habitat at Ocean Beach for this goby, therefore this project will have no impact at all on this species.

The **western snowy plover *Charadrius alexandrinus nivosus*** inhabits the central portion of western north America, principally along the coast from southern Washington State to Baja California and eastward to the mid-west. The entire north American population has been estimated to be between 5500 and 10,000 birds. They are preyed upon by gulls, corvids, small mammals, domestic pets, and raptors.

The Pacific coast population of snowy plover breeds primarily on coastal beaches from southern Washington to southern Baja, California. In addition, large numbers winter along the coast, but there is a trend toward reduced numbers and breeding in coastal locations. Coastal nesters number around 1700. Some coastal populations may resident while some winter along the coast and nest at inland locations. It is not clear whether birds that are coastal nesters interbreed with those that nest inland. Limited breeding habitats on sandy beaches are due to dune stabilization from planting European (marram) beach grass, recreational development, driftwood resulting from logging, and traffic

Plovers breed from April to July, and tend to nest in areas with blowing sand and high susceptibility and to wave action. They also have a tendency to re-nest on disturbed sites. The preferred nesting sites are sand spits and dune-backed beaches with some coastal wetlands nearby. Diet data is scanty, but apparently plovers dine on a mix of invertebrates and shallow lentic water organisms, which may explain the selection of dune nesting sits near coastal wetlands.

Other nesting habitats exist in the form of salt pans, dredge disposal sites, dry salt ponds, and salt pond levees. The inland breeding population numbers around 350 birds

in the San Francisco Bay and Delta. Baumberg Tract, Coyote Tract, and Newark Tract are the three main nesting sites. Habitat alterations and outright destruction limit suitable nesting sites, although San Francisco Bay salt ponds and similar developments may be beneficial to this species.

Historically, there were at least 80 nesting sites on the west coast; 28 remain today. The plover's numbers have declined due to human activity on the beaches during nesting season. Jogging, off-road vehicles, pets, and horseback riding either destroy the nests outright, or cause adults to leave incubating eggs. European beach grass is considered a secondary threat because it has been planted to stabilize dunes and grows so thickly that it reduces available nesting habitat. The snowy plover was listed as threatened on March 5, 1993 (58 FR 12864).

There are no historic records of nesting at Ocean Beach. There are recent observations of territorial behavior at Ocean Beach, and of nesting at Point Reyes, 30 miles to the northwest. Plovers have been observed wintering in some numbers at Ocean Beach and Crissy field on the Presidio of San Francisco. Ocean beach has some suitable habitat where the beach is wide and flat and there is open sand in front of the dunes. The heavy recreational use of the beach by people and their pets is likely to prevent success if nesting is attempted by these birds. However, the present status of nesting at Ocean Beach is unknown. Project impacts are expected to be limited to displacement to other parts of the beach during dune construction. The heavy recreational use of the beach would preclude any chance of successful nesting.

The **Presidio (Raven's) manzanita** ***Arctostaphylos hookeri*** **var.** ***raveni*** is endemic to serpentine soils on the San Francisco peninsula. Colonies of this plant exist at the Presidio of San Francisco, and at the Strybeg Arboretum in Golden Gate Park. There is no serpentine soil at Ocean Beach, and the manzanita has not been observed there.

The **beach layia** ***Layia carnosa*** is a sand dune community flower that probably once existed at Ocean Beach. The layia has not been observed at Ocean Beach.

The **marsh (swamp) sandwort** ***Arenaria paludicola,*** a perennial herb of the Pink family, occurs in coastal swamps and freshwater marshes associated with more or less stable dune systems. This flower's historic range extended from Washington State to San Bernardino County, California. In California, historic populations were known in San Francisco, Santa Cruz, San Luis Obispo, and San Bernadino Counties. Loss of coastal wetland habitat from urbanization, alteration of hydrology from agriculture, competition from exotic species, and the alteration of dune habitat by off-road vehicles are the causes of this species decline. The sandwort was listed endangered August 3, 1993 (58 FR 41378). Black Lake Canyon, which bisects the Nipomo Dunes Mesa in southwest San Luis Obispo

County, is home to the only known California population. Suitable habitat for this species does not exist in the project area.

Proposed species

The **Presidio clarkia *Clarkia franciscana*** and 12 other plants endemic to serpentine soils in California were proposed for listing on December 14, 1992 (57 FR 59053). Serpentinite formations in the San Francisco Bay region are from intrusive igneous rock associated with fault zones in sedimentary Franciscan rocks. Serpentine soils are derived from ultramafic rocks such as serpentinite, dunite, and perioditite which are found in discontinuous outcrops in the California coast ranges and in the Sierra Nevada. Most serpentine soils are formed in place over parent rock and are shallow, rocky, and highly erodible. Typically, high concentrations of magnesium, chromium, and nickel, and low concentrations of calcium, nitrogen and phosphorous make these soils inhospitable to most plants. There are serpentine soils and their associated grassland communities in San francisco and Alameda Counties. The nearest serpentine grassland and the *clarkia* are two miles from Ocean Beach on the Presidio of San Francisco.

One known population of **Marin dwarf-flax *Hesperolinon congestum*** exists in San Francisco County at the Presidio of San Francisco. This species is also dependent on serpentine soils and can be found near the endangered Raven's manzanita. As with the clarkia, loss of serpentine habitat from urbanization, road maintenance, and recreational traffic contribute to its decline. There are no serpentine rocks or soils at Ocean Beach and there should be no impacts, direct or indirect, to this species from this project.

The **San Francisco lessingia *Lessingia germanorum* var. *germanorum*** is a small yellow flower of the Aster tribe. Five populations of the flower are known to exist on the Presidio of San Francisco; a sixth is located on San Bruno Mountain in San Mateo County, California. The lessingia is a coastal dune scrub species. Over 90% of this habitat has been lost in San Francisco from coastal development, construction of fortifications at the Presidio, and the planting of the Presidio forest. Endangerment continues today from recreational traffic and from competition by exotic plants. There is no coastal dune scrub habitat at the sites of the proposed project, and the flower has not been observed at Ocean Beach.

Candidate species

The adult **green sturgeon *Acipenser medirostris* has a** range in the Pacific Ocean from Japan across the north Pacific to Baja, California, and to depths of 400 feet. During the summer, adults occupy the lower estuary and spawn there. Typically, all of the sturgeon species are long lived, and slow to mature. This is a bottom dwelling fish that feeds on

invertebrates, and is not likely to occupy the high energy environment near shore at Ocean Beach

The **longfin smelt** ***Spirinchus thaleichtys*** is an inshore species found from San Francisco Bay northward to Alaska. Apparently a year around resident in San Francisco Bay, adults migrate upstream in the fall to spawn. Concern for this species stems for competition by the introduced threadfin shad *Dorosoma petenense* and the inland silverside *Menidia beryllina*. The longfin could be found in shallow water offshore of Ocean Beach, but ~~it~~ in unlikely that the action alternatives would have and effect on this species.

Formerly widespread in the central valley, the **California tiger salamander** ***Ambystoma tigrinum californiense*** prefers the quiet waters of reservoirs, lakes, ponds, streams, and temporary rain pools in grasslands and open woodland habitats. Adults undertake local migrations during the rainy season, but spend most of their time underground in the burrows of ground dwelling mammals. The tiger salamander is a temperate to subtropical species generally found in arid sagebrush to grasslands to mountain meadows, the California subspecies can also be found from Sonoma County to Point Conception along the coast. Modern agriculture and urbanization are the principle causes of habitat loss. Ponded habitat may exist in Golden Gate Park or near Lake Merced It is unlikely that the tiger salamander could be found in the project area, because of the lack of woodland habitat at Ocean Beach. No impacts to this species are expected from the proposed project.

The geographic range of the **California red-legged frog** ***Rana aurora draytonii*** extends from near the Oregon border southward to Northern Baja California. This frog commonly inhabits ponds and other more or less permanent bodies of water from sea level to 8,000 feet. This amphibian also frequents moist forests, grasslands, and riparian areas where emergent aquatic vegetation or forest understory provide adequate cover. During the rainy season, frogs may be found some distance from permanent water. Formerly a significant source of frog legs for human consumption, today, its decline is attributed to habitat disturbance and to competition from the introduced bullfrog *Rana catesbeiana,* the bluegill *Lepomis macrochirus,* and the Mosquitofish *Gambusia affinis*. Since suitable habitat for the red-legged frog lies does not exist at Ocean Beach, there should be no impact on this species.

The **foothill yellow-legged frog** ***Rana boylei*** is a stream or river frog associated with woodland chaparral that may be found on sunny, rocky stream banks or in riffles. Its range is west of Cascades in central Oregon along the Coast Ranges and the Sierras southward to the san Gabriel river drainage, excluding the central valley. Suitable habitat for this frog does not exist at Ocean Beach.

The **southwestern pond turtle** ***Clemmys marmorata pallida*** is a woodland, or open grassland species occurring from sea level to 6,000 feet westward of the Sierra Nevada Mountains. This subspecies is found from San Francisco Bay to Northern Baja California. The pond turtle can be found in or near permanent marshes, streams, and ditches that have abundant aquatic vegetation. Filling of wetlands and habitat alteration appear to be the cause of its decline. Suitable habitat for the San Francisco subspecies exists in Golden Gate Park and around Lake Merced. Since the most probable habitat for the western pond turtle lies outside the area affected by project construction, there should be no direct impact on this species; indirect impacts are unlikely.

In the genus of rodents known collectively as packrats, the **San Francisco dusky-footed woodrat** ***Neotoma fuscipes annectens*** is our local variety of this western rodent. The range of the dusky-footed woodrat extends from the Columbia River to northern Baja, California. They are commonly found in the coast ranges and eastward to Sierras and the Cascades, excluding the hotter portions of the central valley. Woodrats build stick houses on rock ledges, in trees around the bases of cacti, or on the ground, depending on the locale. Their preferred habitats include: chaparral, streamside thickets or deciduous or mixed forests. Live oaks are a popular nest tree when they are available. Suitable habitat for the San Francisco subspecies exists in Golden Gate Park and around Lake Merced. Possible habitat may exist at the Fort Funston cliffs, just south of the project site. The presence of this subspecies is not expected, except as a possible casual visitor, at Ocean Beach and the proposed project should not affect this creature in any way.

The **Pacific western big-eared bat** ***Plecotus townsendii townsendii***, a more or less colonial species, roosts in caves, mine tunnels, and buildings. Its range covers the western United States into Mexico, and eastward from Kansas in a narrow strip to western Virginia. There are no roosting sites at Ocean Beach, so there should be no impact to this species.

Largest of the freetail bats, the **greater western mastiff-bat** ***Eumops perotis californicus*** roosts on or in buildings crevices, trees, and tunnels. Its range is from San Francisco Bay southeastward to northern Mexico and west Texas. The project area is at the margin of this bat's reported range and the proposed work is not expected to have and impact to this species.

The globose **dune beetle** ***Coelus globosus*** and the **bumblebee scarab beetle** ***Lichnanthe ursina*** are two dune dwelling insects that could occur ar Ocean Beach. These two beetles were not present in recent surveys conducted at Ocean Beach.

The plants listed below are candidate species that are rare, extinct, or are not likely to grow at Ocean Beach because the habitat for them has been disturbed. In any case, none have been observed 'at Ocean Beach. Species accounts for the six plants not discussed will be prepared for the F4 submission.

Franciscan manzanita *Arctostaphylos hookeri* ssp. *franciscana*

As the common name implies, the **San Francisco gumplant *Grindelia maritima*** is endemic to the San Francisco peninsula. It is only known from San Francisco and San Mateo Counties, and grows on the Presidio of San Francisco. It could grow at Ocean Beach, but it has not been observed there.

Bay matchweed *Gutierrezia californica*

Diablo rock-rose *Helianthella castanea*

A sand dune and sand hill species, the **wedged-leaved horkelia *Horkelia cuneata* spp. *sericea*** grows in Contra Costa, Santa Cruz, Monterey, San Luis Obispo, and Santa Barbara Counties. This wildflower will not be found in the project area because there is no suitable habitat.

San Francisco owl's-clover *Orthocarpus floribudus*

The San Francisco popcornflower *Plagiobothrys diffusus* was known historically from San Francisco and Santa Cruz Counties in valley grassland habitats. This flower was probably never resident at Ocean beach. The popcornflower is presumed to be extinct by the California Native Plant Society.

Adobe sanicle *Sanicula maritima*

Marin checkermallow *Sidalcea hickmanii* ssp. *viridis*

The **Mission Delores campion *Silene verecunda* ssp. *verecunda*** is a perennial herb of the Pink family that inhabits grassy or scrubby areas covering the sandy and rocky soils of coastal strand or coastal prairie habitats. The two known populations of the campion in Santa Cruz County are from Swanton and Arroyo Las Trancas. The nearest known population to Ocean Beach is on the Presidio of San Francisco two miles away.

§ 12 COORDINATION DOCUMENTS

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

In Reply Refer To:
1-1-94-SP-743

March 24, 1994

Mr. William C. Angeloni
Chief, Planning and Engineering Division
Army Corps of Engineers - San Francisco
211 Main Street
San Francisco, California 94105-1905

Subject: Updated Species List for the Ocean Beach Storm Damage Reduction Study, City and County of San Francisco, California

Dear Mr. Angeloni:

As requested by your memo from your agency dated March 10, 1994, you will find enclosed an updated list of the proposed and listed endangered and threatened species that may be present in the subject project area. (See Enclosure A.) This list fulfills the requirement of the Fish and Wildlife Service (Service) to provide a species list pursuant to Section 7(c) of the Endangered Species Act, as amended, (Act).

Pertinent information concerning the listed species life history and distribution, and a discussion of the responsibilities of federal agencies under Section 7(c) of the Act were provided for those species addressed in response to your initial request for a species list. Attached is information concerning those listed species not previously addressed.

Formal consultation, pursuant to 50 CFR § 402.14, should be initiated if you determine that a listed species may be affected by the proposed project. If you determine that a proposed species may be adversely affected, you should consider requesting a conference with our office pursuant to 50 CFR § 402.10. Informal consultation may be utilized prior to a written request for formal consultation to exchange information and resolve conflicts with respect to a listed species. If a biological assessment is required, and it is not initiated within 90 days of your receipt of this letter, you should informally verify the accuracy of this list with our office.

Also, for your consideration, we have included a list of the candidate species that may be present in the project area. (See Enclosure A.) These species are currently being reviewed by the Service and are under consideration for possible listing as endangered or threatened. Candidate species have no protection under the Endangered Species Act, but are included for your consideration as it is possible that one or more of these candidates could be proposed and listed before the subject project is completed. Should the

biological assessment reveal that candidate species may be adversely affected, you may wish to contact our office for technical assistance. One of the potential benefits from such technical assistance is that by exploring alternatives early in the planning process, it may be possible to avoid conflicts that could otherwise develop, should a candidate species become listed before the project is completed.

Please contact Laurie Stuart Simons of this office at (916) 978-5408 extension 330, if you have any questions regarding the enclosed list or your responsibilities under the Endangered Species Act. For questions concerning the threatened winter-run chinook salmon, please contact Jim Lecky, Endangered Species Coordinator, at the National Marine Fisheries Service, Southwest Region, 501 West Ocean Boulevard, Suite 4200, Long Beach California 90802-4213, or call him at (310) 980-4015.

Sincerely,

for Dale A. Pierce
Acting Field Supervisor

Enclosures

cc: FWS-SFO (CE Projects, Rich DeHaven), Sacramento, CA
NMFS (Attn: Jim Lecky), Long Beach, CA

ENCLOSURE A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR IN THE AREA OF THE PROPOSED OCEAN BEACH STORM DAMAGE REDUCTION STUDY, CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA (1-1-94-SP-743, MARCH 24, 1994)

Listed Species

Fish
- winter-run chinook salmon, *Oncorhynchus tshawytscha* (E)
- tidewater goby, *Euclyclogobius newberryi* (E)

Birds
- western snowy plover, coastal population, *Charadrius alexandrinus nivosus* (T)

Plants
- Presidio manzanita, *Arctostaphylos hookeri* var. *ravenii* (E)
- beach layia, *Layia carnosa* (E)

Proposed Species

Amphibians
- California red-legged frog, *Rana aurora draytonii* (PE)

Plants
- swamp sandwort, *Arenaria paludicola* (PE)
- Presidio clarkia, *Clarkia franciscana* (PE)
- Marin dwarf-flax, *Hesperolinon congestum* (PT)

Candidate Species

Fish
- green sturgeon, *Acipenser medirostris* (2R)
- longfin smelt, *Spirinchus thaleichthys* (2R▪)

Amphibians
- California tiger salamander, *Ambystoma californiense* (2▪)
- foothill yellow-legged frog, *Rana boylei* (2)

Reptiles
- southwestern pond turtle, *Clemmys marmorata pallida* (2)

Mammals
- San Francisco dusky-footed woodrat, *Neotoma fuscipes annectens* (2)
- Pacific western big-eared bat, *Plecotus townsendii townsendii* (2)
- greater western mastiff-bat, *Eumops perotis californicus* (2)

Invertebrates

globose dune beetle, *Coelus globosus* (2)
bumblebee scarab beetle, *Lichnanthe ursina* (2)

Plants

Franciscan manzanita, *Arctostaphylos hookeri* ssp. *franciscana* (1**)
San Francisco gumplant, *Grindelia maritima* (2)
bay matchweed, *Gutierrezia californica* (2R)
Diablo rock-rose, *Helianthella castanea* (2)
wedge-leaved horkelia, *Horkelia cuneata* ssp. *sericea* (2)
San Francisco lessingia, *Lessingia germanorum var. germanorum* (1)
San Francisco owl's-clover, *Orthocarpus floribundus* (2)
San Francisco popcornflower, *Plagiobothrys diffusus* (2*)
adobe sanicle, *Sanicula maritima* (2)
Marin checkermallow, *Sidalcea hickmanii* ssp. *viridis* (2)
Mission Delores campion, *Silene verecunda* ssp. *verecunda* (2)

(E)--Endangered (T)--Threatened (P)--Proposed (CH)--Critical Habitat
(1)--Category 1: Taxa for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.
(2)--Category 2: Taxa for which existing information indicated may warrant listing, but for which substantial biological information to support a proposed rule is lacking.
(1R)-Recommended for Category 1 status.
(2R)-Recommended for Category 2 status.
(■)--Listing petitioned.
(*)--Possibly extinct.

D R A F T

Preliminary Draft Coordination Act Report

Ocean Beach Storm Damage Reduction Study

San Francisco, California

prepared by
U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento, California

prepared for
U.S. Army Corps of Engineers
San Francisco District
San Francisco, California

September 1993

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PREFACE

This is the Fish and Wildlife Service's (Service) detailed report on the anticipated effects of the Corps of Engineers' (Corps) proposed Ocean Beach Storm Damage Reduction Project on fish and wildlife resources. The report has been prepared under authority of, and in accordance with, the provisions of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; U.S.C. et seq.). This report supersedes all letters and reports previously prepared by the Service for this proposed project.

The purposes of this report are to (1) evaluate the impacts of the selected construction and management alternative(s) on fish and wildlife resources and their habitats, and (2) recommend appropriate measures for preserving, compensating, and enhancing fish and wildlife resources. Our analysis is based on engineering and other project information provided in the Corps' letter dated March 1, 1993, the Scope of Work for Fiscal Year 1993 dated October 1992, and the Corps' Reconnaissance report for the Ocean Beach Storm Damage Reduction Study dated March 1992. Our description of biological resources in the study area is based on field investigations and surveys, literature review, and personal communication with experts knowledgeable about the resources in the area.

Mitigation recommendations in this report are based on the Service's Mitigation Policy (Federal Register 46:15; January 23, 1981) which provides internal agency guidance for developing appropriate mitigation for projects

under the Service's purview. Under the Policy, each distinct, mappable fish and wildlife habitat type to be potentially impacted by a project is assigned to one of four Resource Categories to ensure that recommended mitigation is consistent with the fish and wildlife habitat values involved. The Resource Categories cover a range of habitat values from those considered to be unique and irreplaceable to those believed to be relatively low in value to fish and wildlife. Each of the Resource Categories also has specific mitigation goals.

Specifically, the Resource Categories are: (1) those habitat areas of high value for the evaluation species which are also unique and irreplaceable (Resource Category 1); (2) those habitat areas of high value for the evaluation species which are either scarce or becoming scarce (Resource Category 2); (3) those habitat areas of high to medium value for the evaluation species which are relatively abundant (Resource Category 3); and (4) those habitat areas with medium to low value for the evaluation species (Resource Category 4). The Service's respective mitigation planning goals for these Resource Categories are: (1) no loss of existing habitat value; (2) no net loss of in-kind habitat value; (3) no net loss of habitat value, while minimizing loss of in-kind habitat value; and (4) minimize loss of habitat value.

Because we anticipate that the net impact of the selected alternative would be relatively minor, and the project would likely be self-mitigating, we have used an abbreviated habitat-based assessment. This assessment approach is a modified and simplified version of the Service's Habitat Evaluation Procedures

(HEP), but nevertheless provides a habitat-based approach to resource assessment and a means to calculate an index of habitat values using both qualitative and quantitative factors. The habitat types used by wildlife are appraised with respect to their general, overall value in providing necessary habitat requirements for key species which use them. For this assessment, habitat value is displayed as CUs (compensation units), the product of habitat quality and area. The objectives of this assessment were to better define (in nonmonetary terms) the impacts of the project, and to provide a basis for quantifying compensation measures needed to offset the unavoidable adverse impacts of the project, if any.

Neither the Mitigation Policy nor our selected habitat-based assessment are used to address or evaluate project impacts to and mitigation needs for federally-listed endangered or threatened species. These species' needs are considered separately, as provided for in the Endangered Species Act of 1973, as amended.

This letter has been coordinated with the California Department of Fish and Game and National Marine Fisheries Service.

INTRODUCTION

The purpose of the Ocean Beach Storm Damage Reduction Project would be to use sand dune creation as a method of reducing wind and storm-induced erosion of existing dunes at Ocean Beach. Continued erosion of the existing dunes would

continue to threaten the Great Highway and West Side Sewer Transport Box. This report describes fish and wildlife resources found within the project area and the impacts the proposed actions presently being investigated by the Corps may have on these resources.

DESCRIPTION OF THE AREA

The Ocean Beach study and project area (Figures 1 and 2) is located along the western boundary of the city and county of San Francisco, just south of the Golden Gate Bridge. Historically, the San Francisco peninsula supported one of the four largest sand dune communities along the California Coast (Powell, 1978). Today it is one of the few remaining remnants of dune habitat along the California Coast. The project area encompasses a 3.3-mile reach extending from the Cliff House south to the Fort Funston bluffs. The beach and dune area varies in width from about 450 feet at its widest point (south of Judah Street) to about 175 feet at the narrowest point (near Golden Gate Park). The average width is about 250 feet. The entire beach and dune area presently measures about 34 acres.

All of Ocean Beach west of the Great Highway right-of-way is owned and managed by the National Park Service and is part of the Golden Gate National Recreation Area (GGNRA). The project area experiences high public use. Recreational activities include fishing, surfing, picnicking, walking, jogging, bicycling, and general nature appreciation activities, such as bird-watching.

The dunes at Ocean Beach are known as foredunes - characteristically mobile, active, and unstable. In a natural, undisturbed dune ecosystem, foredunes generally function in providing or "feeding" the inner (inland) dunes with sand. However, because of the intensive development that currently exists inland of Ocean Beach today, this natural process results in potential damage to these human-made structures.

Several theories exist regarding natural sand nourishment at Ocean Beach. Possibilities include transport from a massive, shallow, underwater sandbar outside of the Golden Gate, with northward littoral drift, and/or transport from the Merced formation, south of Ocean Beach (Cooper 1967).

Ocean Beach sand consists of recent beach deposits bordered by dune deposits. South of Golden Gate Park, beach deposits are bordered by artificial fill placed for shoreline protection and the construction of the Great Highway (a four-lane highway) and San Francisco Zoo. In 1929 to 1930, the Great Highway was constructed between Lincoln Way and Fort Funston on a human-made berm. The berm, created by the placement of an estimated 1,260,000 cubic yards of sand on Ocean Beach westward of the original shoreline, modified the profile of the beach. Sand on the beach is composed of graywacke, sandstone shale, jasperchert, serpentine and schist formations (USFWS 1990).

The O'Shaughnessey Seawall, completed in 1929, is located from north of Fulton Street to Lincoln Way. The Great Highway Seawall and Promenade, located

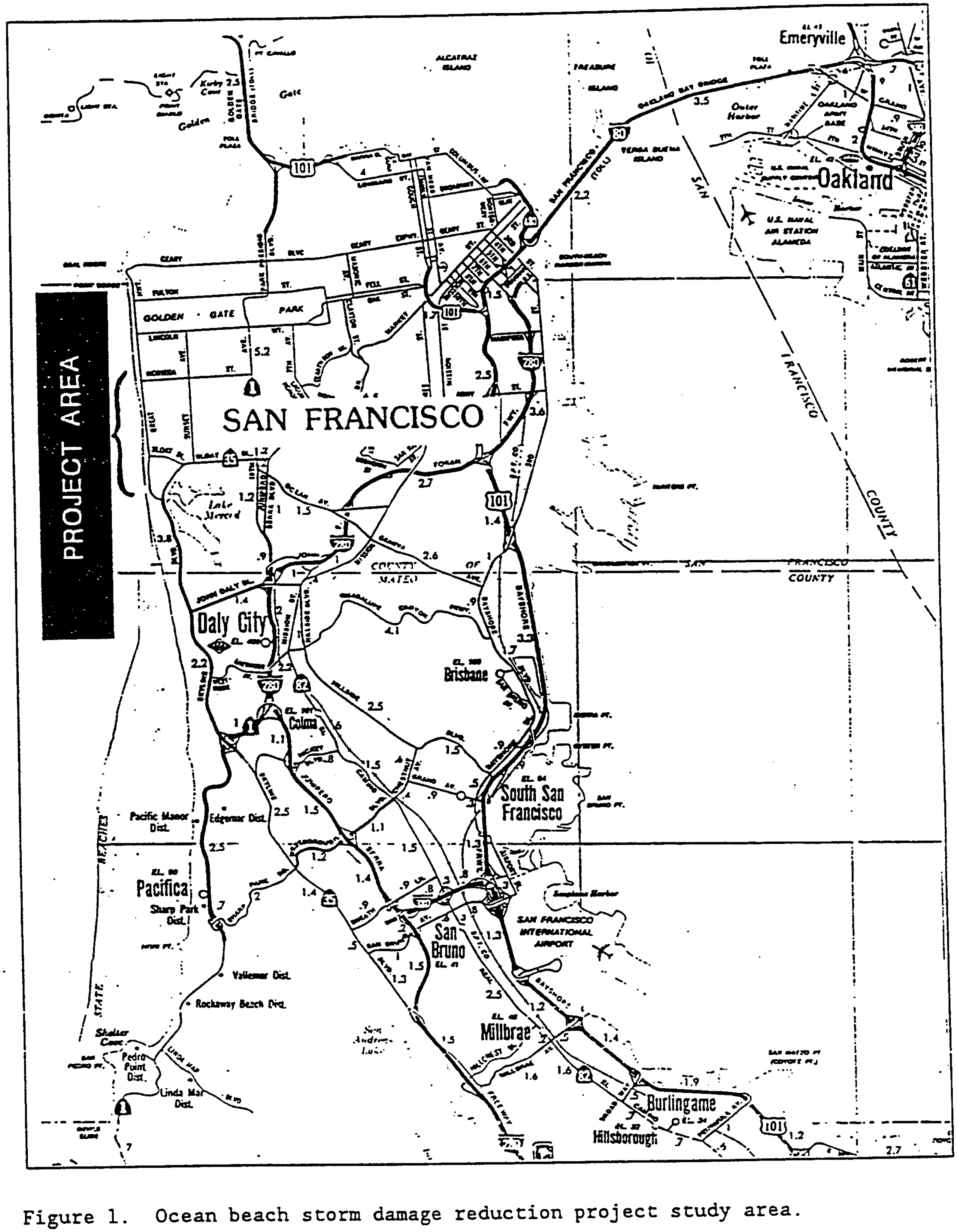

Figure 1. Ocean beach storm damage reduction project study area.

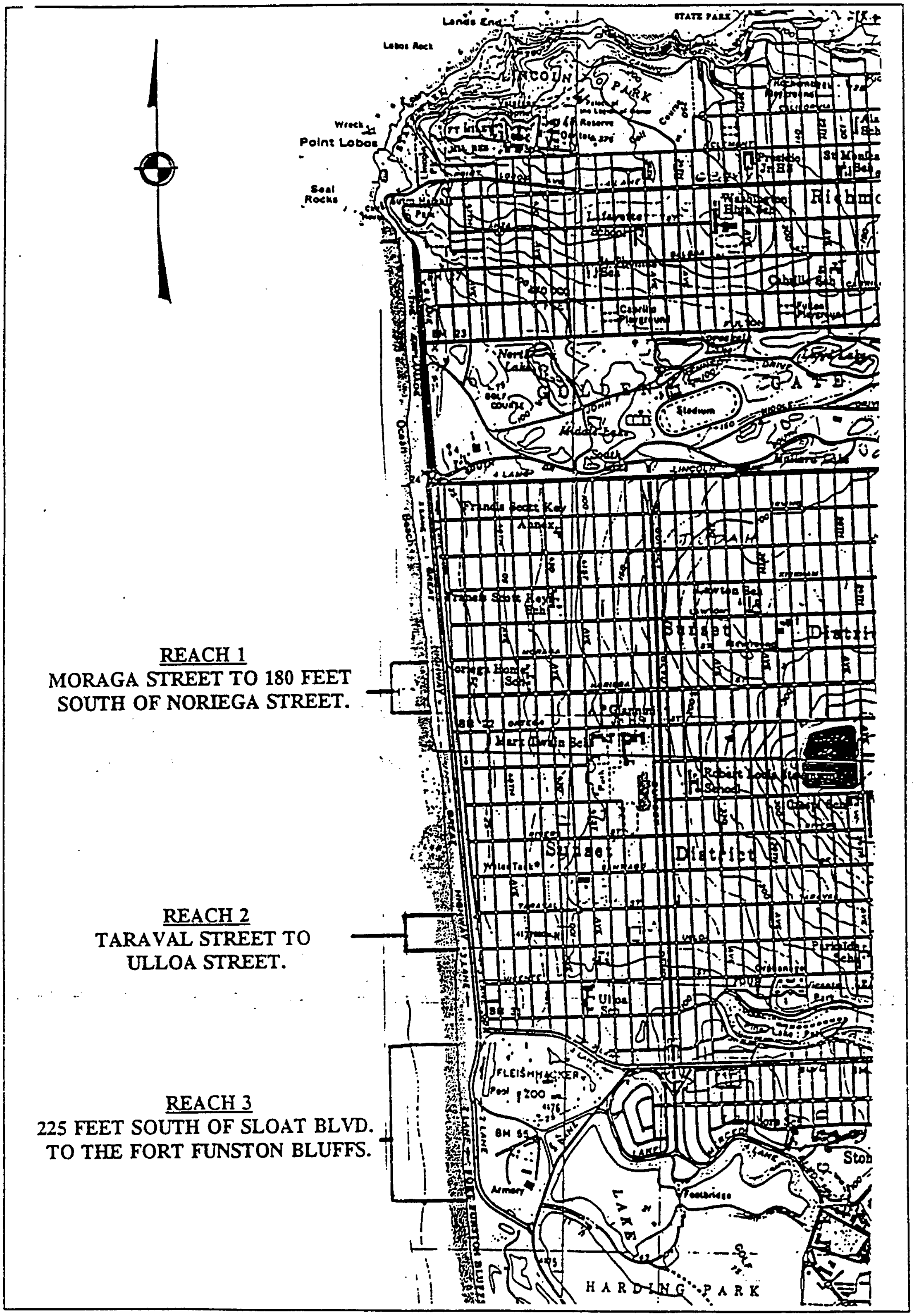

Figure 2. Ocean beach storm damage reduction project reaches.

between Ortega and Santiago Streets, and the Taraval Seawall, located between Santiago and Taraval Streets, are also found at Ocean Beach. These seawalls are located on city property. When the O'Shaughnessey Seawall was constructed, the city of San Francisco used sand fill to extend the beaches seaward as much as 200 feet to construct the Great Highway. Since construction of the seawalls in the early 1900's, approximately 2.3 miles of these reaches have been threatened by severe wave erosion, resulting in the loss of tens of thousands of cubic yards of sand annually (USFWS 1990).

Erosion in the study area is caused primarily by storm-induced wave activity and wind, and secondarily by other natural processes such as regular wave action, and subsidence and land movement. Erosion at Ocean Beach potentially threatens existing dune habitat and associated fauna and flora, recreational activities, local infrastructure, public property, the Great Highway, the West Side Sewer Transport Box (a major sewage transport for West San Francisco), and existing seawalls. Other areas adjacent to Ocean Beach have experienced similar problems. Phelan Beach, which lies 1 mile northeast of the study area, is often denuded of sand, exposing large areas of underlying rock.

DESCRIPTION OF THE PROJECT

The proposed Ocean Beach Storm Damage Reduction Project presently includes the analysis of two alternatives: no Federal action and the dune nourishment alternative. The period of analysis is 51 years, consisting of a 50-year project life plus a construction period of 1 year. The two alternatives are described as follows:

Alternative 1 - No Federal Action

Under the no Federal action scenario, erosional processes at Ocean Beach would continue to erode existing sand dunes as under current conditions, via wave and wind forces. Wave erosion would continue at an average rate of 2 to 5 feet annually along the study area. Under these conditions, the Great Highway and associated West Side Sewer Transport Box would be increasingly threatened by storm-induced wave erosion and damage.

Alternative 2 - Dune Nourishment

The selected dune nourishment alternative would involve the placement of large quantities of sand along three reaches of beach (Figure 2) at Ocean Beach to create sand dunes. The artificial fill would be used to widen existing dunes, providing a sacrificial buffer zone, thereby reducing wave-induced erosion of the backshore. The borrow site for obtaining the fill material has not yet been determined; however, it might be obtained from an existing commercial site in San Francisco Bay near Angel Island (Madalon, pers. comm.).

Two methods of sand placement are being considered. One option is to pump sand to the construction sites from a barge, using a slurry pipeline. Bulldozers would then be used to form the dunes. The second option would involve transporting the sand to the project site by truck.

In order to accommodate the placement of new sand, some sand would be removed from the seaward side of the existing dunes to form the appropriate slope.

Sand would be deposited at the seaward dune slope, gradually building the dune toward the ocean. Periodic and subsequent nourishment of the dunes is expected to be required about every 10 years in order to ensure adequate protection. The created dunes would be planted with native plant species for stabilization purposes.

Three specific reaches along Ocean Beach have been identified as needing protection (Figure 2). Reach 1 extends from Moraga Street to 180 feet south of Noriega Street (870 lineal feet). Existing dunes would be built out to a width of about 150 feet, and a height of about 34 feet above mean lower low water (MLLW), or about equal to the height of existing dunes. The erosion rate in this reach is estimated at 5 feet per year. About 25,500 cubic yards of sand would be required for initial construction. In addition, about 51,500 cubic yards would be needed for each subsequent nourishment effort.

Reach 2 extends from Taraval Street south to Ulloa Street (700 lineal feet). About 16,000 cubic yards of sand would be needed for initial build-out of the existing dunes to the 120-foot width. The erosion rate in this reach is estimated at 2 feet per year.

Reach 3 extends from 225 feet south of Sloat Boulevard south to the Fort Funston Bluffs, a linear distance of 2,375 feet. About 128,100 cubic yards of sand would be needed to widen the existing dunes to 120 feet. An average annual erosion rate of 2 feet per year is estimated for this reach. A combined total of 5,840 cubic yards of sand would be needed for each subsequent renourishment effort for the above two reaches.

BIOLOGICAL RESOURCES

Existing Resources

The coastal shore in this area is identified by the Service's National Wetland Inventory as either protected or unprotected rocky or sandy shores (beaches). Protected shores are further identified by a headland which extends out from the beach, providing some wave protection to fragile organisms on sand or rock substrate. Unprotected sandy shores characteristically support less species diversity than the protected areas (USFWS 1990). Current (November 1993) estimated acreages for dunes in the three project reaches are: 2.03 (Reach 1), 1.72 (Reach 2), and 1.35 (Reach 3).

Vegetation. The major plant communities at Ocean Beach can be classified as coastal strand; they are not inundated by seawater, but are adapted to, and influenced by salt spray, mist, fog, and blowing/drifting sand. Vegetative cover in the project area is sparse to moderate, depending on the location of the site, level of disturbance to the site, and type of vegetation.

Existing sand dunes at Ocean Beach are dominated by the introduced European beach grass (*Ammophila arenaria*). This species was first introduced to San Francisco in 1869 for the purpose of dune stabilization (Cooper 1967). Despite the aggressive and invasive nature of European beach grass, several native plant species are still found inhabiting sand dunes and nearby small bluffs in the project area. Many of these plants are found on embryo (early

forming) dunes along the beach as well as on the larger, established dunes. In addition, a restoration planting effort has been implemented by the National Park Service near the Fort Funston Bluffs, on the inland slope of the dunes. This area is relatively well-protected from wind and human disturbance, which has helped aid in the thusfar successful establishment of a diversity of native plantings.

Native plant species that presently occur or have historically occurred in the project area include native dune grass (*Elymus mollis*), beach strawberry (*Frageria chilensis*), yellow sand verbena (*Abronia latifolia*), dune tansy (*Tanacetum douglasii*), and beach pea (*Lathyrus littoralis*). Introduced species other than European beach grass include New Zealand sea spinach (*Tetragonia expansa*), sea rocket (*Cakile maritima*), and two species of iceplant: sea fig (*Mesembryanthemum chilense*) and hottentot fig (*Mesembryanthemum edule*). A more complete plant list for the project area is found in Appendix A.

The littoral zone is dominated by dinoflagellates (e.g., Gymnodinium and Ceratium spp.) which make-up the food base for primary consumers; various species of phytoplankton may also be found. Algae are uncommon in the unprotected, sandy, littoral zone (USFWS 1990).

Invertebrates. The marine environment at Ocean Beach supports a diverse collection of invertebrates. McCormick (1992) conducted seasonal surveys for intertidal, subtidal benthic and subtidal epibenthic (above the ocean floor) invertebrates, one in late Winter (March 1992) and one in the Fall

(October/November 1991). Sampling resulted in identification of 53 taxa, 38 of which were identified to species. Arthropoda dominated Ocean Beach invertebrate fauna in terms of species richness. Crustacea comprised the majority of Arthropods. In terms of number of individuals, Arthropods dominated the intertidal and subtidal epibenthic surveys, while Echinodermata, composed primarily of sand dollars (*Dendraster exentricus*), were dominant in the benthic surveys. Sand dollars are also very common along the beach shore.

The most characteristic invertebrate inhabitants of the beach habitat are the great beach hopper (*Orchistoidea corniculata*), the mole crab (*Emerita analoga*), the Pismo clam (*Tivela stultorum*), razor clam (*Siliqua patula*), short-spined starfish, a nephtyid polychaete worm (*Nephtys californensis*), and various species of jellyfish. These animals are well-adapted to conditions specific to their habitat. The beach hopper remains buried during the day, exiting at night to feed. The mole crab, used as bait by shore fisherman, relies on rapid digging to avoid being washed out with the surf. Pismo clams are slower diggers, and have developed heavy shells in response to pounding waves. Sand dollars (*Dendraster exentricus*) are commonly found on the shore. On occasion, scallops, snails or clams are also washed ashore. The purple sailor, jellyfish, and comb jellies are often stranded ashore on the beaches, indicating their presence in the littoral zone (USFWS 1990).

In shallow sand and mud bottoms, assemblages of polychaete worms, crustaceans (amphipods, crabs, and ostracods), molluscs (pelecypods, gastropods, and scaphopods), echinoderms (starfish, brittle stars, heart urchins, sea

cucumbers and sea pens) may be found. Other phyla which may be represented include coelenterates, echiuridans, nematodes, and rhynchocoels.

In the littoral zone, zooplankton are the primary consumers of phytoplankton. Zooplankton include diatoms, protozoans, and smaller crustaceans. Larger secondary consumers include jellyfish, tunicates, and molluscs. All these animals float and drift with the tides and ocean currents.

Several invertebrate groups found in the area are particularly significant economically. The dungeness crab, bay shrimp, blackspot shrimp, sand dollars, and sand or mole crab, are important to the local commercial fishery. Phoxocephalid amphipods, typically small benthic or bottom-dwelling animals less than 1 centimeter in length, are also significant; they provide an important food source for benthic-feeding fish such as English sole and shiner surfperch (McCormick 1992).

Fish. The fishery in the waters along the coast of Ocean Beach is rich in diversity. In shallow water, various perch species and striped bass are generally the two fish species most commonly caught by shore fishermen. Salmon are also caught occasionally (USFWS 1990). Fish sampling conducted for vertebrate and invertebrate ocean species 3 to 4 miles offshore by San Francisco's municipal clean water program indicates that at least 50 species of fish may be found in the study area. Some of these include sharks, skates, ratfish, midshipman, pipefish, poachers, sculpins, surfperch, goby, ling cod, snailfish, rockfish, halibut, sole, flounder, and turbot (City of San Francisco Clean Water Program 1990). In addition, trawling samples conducted

by McCormick (1992) found demersal (near bottom) fish species such as speckled sanddab, spotfin surfperch, sand sole, English sole, shiner surfperch, and Pacific sanddab.

McCormick's previous review of the literature apparently indicated that white croaker, barred surfperch, and striped bass would be expected to occur in the area as well, however, these species were not found during her two surveys. McCormick also noted that English sole, speckled sanddab, and shiner surfperch serve ecological, commercial, or recreational importance in the area.

Depending on the location of the project's borrow site, sandy shoals off the San Francisco Coast could potentially be impacted. These shoals, which are generaly shallow, sandy, typically accreting areas on the ocean floor, provide valuable spawning and nursery areas for numerous fish species, including many of recreational and commercial importance (Jim Bybee pers. comm.). These various species often utilize shoal areas at different times of the year. Sandy shoals also provide valuable rearing habitat for Dungeness crab, a high-value commercial species.

Marine mammals which may frequent the pelagic portions of the ocean (depending upon the season) include California sea lions, Steller sea lions, harbor seals, northern elephant seals, and various dolphins.

Wildlife. Despite the highly urban surroundings and high human disturbance, Ocean Beach provides habitat for several species of wildlife. Avian species observed at Ocean Beach vary seasonally, however, some bird species, such as

cormorants and gulls, are present throughout the year. Other species, including shorebirds, use the area only as nesting or wintering habitat. Loons and grebes, for example, are found in greatest numbers in the area during the fall, winter, and spring, while plovers use Ocean Beach primarily as a wintering area.

Avian species make use of all the habitats in the Ocean Beach study area. Fish-eating birds, such as brown pelican, cormorants, terns, gulls and murrelet, make use of the nearshore waters where they feed on small fish forced toward shore by larger predatory fish. Beach areas are used by shorebirds, such as the sanderling and the western snowy plover, for foraging and for cover. Some of these same species also use the sandy beach and dunes for roosting and/or nesting. A colony of bank swallows nest in the sandy bluffs at Fort Funston (just south of the project area) from roughly April through July. Other birds, such as the housefinch, Brewer's blackbird and common raven may be seen throughout the project area.

Due to the urban setting, high human recreational use and lack of suitable cover, vertebrates other than birds are not abundant. Portions of the study area do, however, provide foraging habitat for small mammals including the house mouse, California ground squirrel, and the California gray squirrel. A few amphibian and reptile species, including the western toad, western fence lizard, gopher snake, and common garter snake also inhabit the area. A list of animal species that may be found at Ocean Beach is included in Appendix A.

Threatened and Endangered Species. The following discussion of federally-listed threatened and endangered species should be regarded as preliminary information, which the Service is providing to assist the Corps in preparation of any necessary Biological Assessments (BAs) for the project. The Corps' responsibilities for such BAs, and for completing other aspects of Section 7(a) and (c) of the Endangered Species Act of 1973, as amended (Act) are briefly outlined in the attached Appendix B. In addition, the Service recommends that the Corps review all of its requirements for compliance with the Act, as published in 50 CFR 402. Generally, it is the policy of the Service's Sacramento Field Office that a *final* FWCA report for a proposed project will not be issued until full compliance with the Act has been achieved.

Both federally-listed and proposed endangered and threatened species and candidate species may occur in the project area (Appendix C). Candidate species are taxa under consideration by the Service for listing as threatened or endangered. Although candidate species are not protected under the provisions of the Act, the 1988 amendments to the Act require the Service to monitor their status. If any such species decline precipitously, they could be listed on an emergency basis. In addition, should a candidate species be listed prior to completion of an otherwise authorized project which may affect the species, the full protection of the Act is afforded the species. It is prudent, therefore, to consider fully the implications of candidate species in project planning.

Plants. Two endangered plants, the Presidio manzanita (*Arctostaphylos hookeri* var. *ravenii*) and the beach layia (*Layia carnosa*) may occur, but are not likely, in the project area. Historically, the beach layia occurred in the project area, but is now believed to have been extirpated from San Francisco County. Three plant species proposed for Federal listing may also be found in the project area: Swamp sandwort (*Arenaria paludicola*) and Presidio clarkia (*Clarkia franciscana*) are proposed as endangered species; Marin dwarf-flax (*Hesperolinon congestum*) is proposed for threatened status.

In addition, a number of candidate plant species may be found in the project area. Among these, the most likely to occur include San Francisco Lessingia (*Lessingia germanorum* var. *germanorum*), San Francisco gumplant (*Grindelia martima*), wedge-leaved horkelia (*Horkelia cuneata* spp. *sericea*), San Francisco owl's clover (*Orthocarpus floribundus*) and Mission Delores campion (*Silene verecunda* spp. *verecunda*).

Invertebrates. No listed invertebrate species are known to occur in the project area. However, two Category 2 candidate species for listing may occur here: the globose dune beetle (*Coelus globosus*) and bumblebee scarab beetle (*Lichnanthe ursina*).

Fish. One listed, one proposed and two candidate fish species may be found in the project area. The winter-run chinook salmon is known to occur off Ocean Beach and is a federally-listed threatened species. The tidewater goby (*Eucyclogobius newberryi*) is a proposed endangered species that may occur in the project area. The green sturgeon (*Acipenser medirostris*) and longfin

smelt (*Spirinchus thaleichthys*), two Category 2 candidate species for listing may also be found in the waters off Ocean Beach.

Birds. The Pacific coast population of the western snowy plover (*Charadrius alexandrius nivosus*), a federally-listed threatened species, is known to use Ocean Beach as a wintering area (Karen Miller, pers. comm.). The species has been using the area consistently since 1979. The number of individuals counted in the area rose significantly in 1985 and has remained at or near that level ever since. Surveys conducted by the Point Reyes Bird Observatory indicate the median number of wintering plovers at Ocean Beach to be between 22 and 35 (Gary Page, pers. comm.). However, up to 65 individuals have been observed in a single season. Nevertheless, the survey data are somewhat incomplete, and numbers of plovers using the Ocean Beach area may actually have been higher in some years (Daphne Hatch, pers. comm.).

Plovers typically use the widest portions of the beach, as these areas provide greater escape in case of predators (Gary Page, pers. comm.). Foraging occurs on the wet sand, in seaweed racks (debris) within the intertidal zone, and in dry sandy areas above the high tide line (Daphne Hatch, pers. comm.). The plover has also been designated a species of special concern by the California Department of Fish and Game.

A nesting colony of the state-listed bank swallow (*Riparia riparia*) is found just south of the project area in the sand bluffs at Fort Funston. This colony is one of just a few isolated bank swallow colonies south of Sacramento. One colony is known to occur at Ano Nuevo State Beach; another

colony has been reported on the Pajaro River but has not been confirmed (Barry Garrison, pers. comm.).

Mammals. No listed or proposed mammals are known to occur at Ocean Beach. However, three Category 2 candidate mammal species, the San Francisco dusky-footed woodrat (*Neotoma fuscipes annectens*), Pacific western big-eared bat (*Plecotus townsendii townsendii*), and the greater western mastiff-bat (*Enmops perotis californicus*), may occur in the project area.

Future Conditions Without the Project

Without the project, the presently existing sand dune habitat at Ocean Beach would continue to erode away from wave and wind action at an annual rate of about 5 feet for Reach 1 and 2 feet for Reaches 2 and 3. At these rates, existing dunes would be completely gone in an average of about 15 years for Reach 1, 50 years for Reach 2, and between 8 and 21 years for Reach 3, depending on the exact location along the reach (calculated from Tables 2.5 and 2.6, Corps of Engineers 1992). As erosion continued, sand dune habitat and the plant and animal life it supports would all gradually diminish.

Portions of Ocean Beach would continue to erode, and subsequently continue to threaten the Great Highway. The highway would also be increasingly vulnerable to periodic sand deposition by wind and storm activity. Additionally, the West Side Sewer Transport Box and the protected sand dunes in the area would be at higher risk of damage or loss due to the erosion.

Future Conditions With the Project

The methodology for the habitat-based assessment which formed the basis of the evaluation of project impacts is provided in Appendix D. Basically, conditions with the selected dune nourishment alternative were compared to anticipated conditions without the project.

With the project, additional dunes would be constructed in each of the three reaches and renourishment would recur every 10 years. Sand dunes in Reach 1 would be extended laterally for a total width of 150 feet; sand dunes in Reaches 2 and 3 would be extended to a total width of 120 feet each. The first year of construction, and each succeeding 10 years, the sand dune area in Reaches 1, 2, and 3 would be built out to acreages measuring 3.00 acres, 1.93 acres, and 3.63 acres, respectively.

Our preliminary assessment indicates that over the life of the project, an estimated net increase of 3.06 AACUs (Average Annual Compensation Units) would occur. Dune nourishment is expected to provide 3.79 AACUs, while only .73 AACUs would occur under without project conditions. These initial numbers do not take into account removal of vegetation during construction; this component will be factored in when final project information becomes available.

Figure 3 provides a graphic comparison of conditions in the project area with and without the project. As indicated, CUs would decrease gradually over time without the project. With the project, however, CUs would increase during

initial sand nourishment, decrease over time (due to continuing erosional processes), then increase again with the re-nourishment efforts; this 10-year cycle would repeat continuously throughout the remaining life of the project.

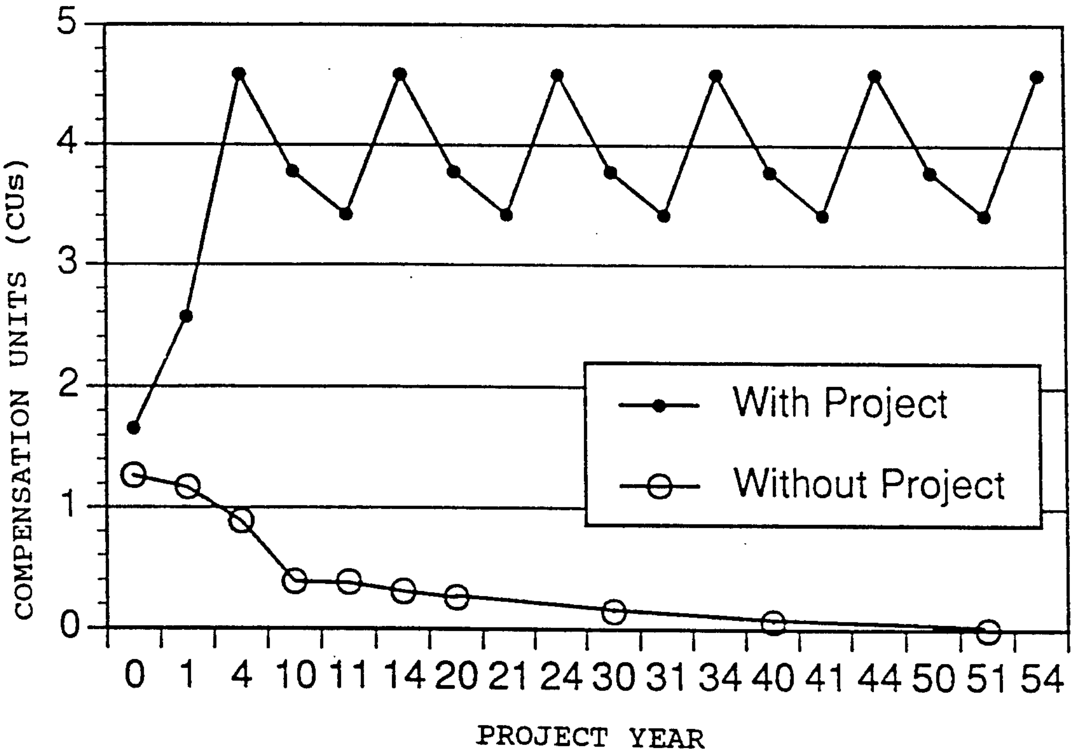

Figure 3. Comparison of Compensation Units (CUs) under with-project and without-project scenarios, Ocean Beach Storm Damage Reduction Project (all reaches combined).

Vegetation. Under with-project conditions, some adverse impact to terrestrial vegetation would occur. A relatively small amount of existing sand dune vegetation, composed primarily of European beach grass, would be removed from the seaward slope of existing dunes to accommodate placement of new sand to build out the dunes. Additionally, a small number of vegetated embryo (newly-forming) dunes on the beach would be covered by the newly-placed sand.

Overall, beneficial results are anticipated from the project in relation to restoration of native sand dune vegetation. Native species would be planted on the newly-created dunes. Native dune habitat would thus be expected to increase by a total of about 4.7 acres for the three reaches for the first year in which the project is implemented. Each successional 10 years, an estimated 7.3 acres of native sand dune habitat would be added. Over the life of the project, a total of about 33.85 acres of sand dunes would thus be created.

In addition, a rapid succession of severe storms or severe weather years could rapidly eliminate the sand placed to nourish the beach, thereby requiring even more frequent dune replenishment, depending upon storm frequency and wave activity. This alternative may also result in increased sedimentation in adjoining areas via ocean drift, thus gradually shifting the location of wave roll-out areas along the beach.

Invertebrates. Implementation of the dune nourishment alternative would result in direct habitat losses of beach habitat, primarily as a result of direct sand placement on the beach. This would adversely impact terrestrial sand-dwelling invertebrates. The severity of impact to these organisms would depend on the selected method of sand placement. If sand is placed incrementally as recommended later in this report, populations are expected to recover fairly rapidly after construction. If sand is placed on the beach in very large quantities at the same time, however, recovery time for these organisms would be much longer, resulting in more significant impacts than

would occur with gradual placement. Impacts to invertebrates would in turn impact organisms higher on the food chain.

Some adverse impacts to aquatic invertebrates are also likely to occur. The level of impacts would depend on the selected location and method of sand mining and transport. Aquatic invertebrates provide an important food source for pelagic- and benthic-feeding fish and other wildlife species.

Fish. Adverse impacts to fish could occur through (1) removing them from the ocean floor during dredging operations, (2) loss of habitat, (3) creating high levels of suspended solids in the water column during construction, and (4) increased contaminant loads by disturbance of contaminated bottom substrates.

Fish would also be indirectly displaced from foraging areas in and around the dredge site during construction. Displacement from spawning and rearing areas could be detrimental to fish and wildlife. Movement or migration along established routes by species such as the Pacific herring could also be interrupted by project activities (USFWS 1991). In addition, entrainment of fish and other aquatic species, such as Dungeness crab, would likely occur at the borrow site. Fish eggs and larvae and sedentary species may be covered with silt and die; adults and more mobile species would be able to leave the area.

The destruction of benthic habitat and its benthos in the dredged area would reduce use of the channel by fishes until natural habitat restoration and repopulation of organisms had taken place. The dredge site would probably be

repopulated with many of the same fish species lost during project construction, but it is unlikely that the original species diversity or population densities would be reestablished.

In addition to physical disturbance of the channel bottom, the possible dredging activities would temporarily increase turbidity and siltation. The direct effects of increased turbidity on fish include (1) inhibition of respiratory exchange through clogging of gills and abrasive action on gill filaments; (2) elimination of spawning areas; (3) reduction of fish feeding ability; and (4) establishment of anaerobic conditions (USFWS 1991). Suspended sediments can clog and damage the gills of many species of fish. Also, because periodic dredging would be required, the channel would be disturbed at regular 10-year intervals, and these impacts would thus be repeated.

Wildlife. Adverse impacts to wildlife that inhabit the beach and dunes would occur primarily through increased disturbance during construction and direct loss of beach habitat as a result of sand placement and stabilization. Impacts to wildlife through removal of small amounts of existing dunes and vegetation would be minor, however.

The considerable amount of construction required during dune nourishment activities would have short-term, yet highly disturbing impacts to wildlife in the project area, as a result of greater noise and human disturbance. The most significant impacts would likely be to bird species, as mammals are uncommon in the area and amphibians and reptiles occur more on existing dunes

than on the beach area, which would receive most of the impacts. Adverse impacts would be especially significant if construction were to occur in the spring months during wildlife breeding periods.

Dune nourishment could also adversely impact beach habitat used by some wildlife species. These impacts would be minimal, however, except possibly in the case of the western snowy plover (see next section). The drier areas of the beach, where most of the dunes would be constructed, offer little in the way of food or cover for most bird species (Small 1974) and the addition of high existing human disturbances decreases its value to wildlife even further. And use of this area by other wildlife species at Ocean Beach is rare.

Threatened and Endangered Species. Ocean Beach is currently being considered for designation as part of the critical habitat for the western snowy plover. Critical habitat, as defined in the Act includes "the specific areas within the geographical area occupied by the species, ... on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection...". Once so designated, significant adverse impacts to this habitat will need to be avoided. Federal actions that would destroy or adversely modify critical habitat as described in the Act, will need to be avoided. "Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species.

The project, as proposed, could adversely modify potential critical habitat for the western snowy plover. The species uses the drier beach areas for roosting in winter months. The western snowy plover is also fairly tolerant of human intrusion, thus using the area despite the high human use. Replacing beach habitat with vegetated dunes would decrease potential wintering habitat. This species prefers areas with less than about 25 percent cover (Page pers. comm.). To minimize adverse impacts to the western snowy plover, some dune area may need to be sparsely vegetated to maintain suitable habitat.

Impacts to the bank swallow colony at the Fort Funston Bluffs is also a potential concern. Adverse effects could result from sand being inadvertently transported by wind forces to the colony area. Should this occur, accumulated sand under the colonies would increase predation by allowing increased predator access to nesting holes. Modeling or other analyses should be completed by the Corps to assess what is likely to happen in this area in regard to sand transport. Should it be determined that the colony area could be impacted by sand build-up, an alternative action should be developed to prevent it. Removal of sand after its accumulation would not be an adequate mitigation measure, because such long-term maintenance commitments of this type are too difficult to ensure.

DISCUSSION

Habitats, Evaluation Species, and Mitigation Goals

As discussed in the Preface section, the Fish and Wildlife Service makes mitigation recommendations based on the value of the habitats in the project area to fish and wildlife species. During impact assessment, distinct habitat types which may be impacted by the project are identified. Evaluation species which utilize each habitat type are then selected for impact analysis. Evaluation species selection is often based on a rationale including: 1) species known to be sensitive to specific land- and water use actions, 2) species that perform a key role in the community because of their role in nutrient cycling or energy flows, 3) species that represent groups of species that utilize a common environmental resource, or 4) species that are associated with Important Resource Problems as designated by the Director or Regional Directors of the Fish and Wildlife Service, such as anadromous fish and migratory birds.

Habitat value determinations are based on the importance of the habitat found in the project area to the selected evaluation species and the relative scarcity of the habitat types. Habitat values can range from those considered to be of high value and unique and irreplaceable to those believed to be of relatively low value to fish and wildlife and generally common. In the project area, sandy beach and sand dune habitats would be affected.

The evaluation species selected to determine the value of the beach habitat in the project area are gulls and shorebirds. Some gulls, such as the western gull, are year-round residents of Ocean Beach. Other species, such as Heerman's gull, which occur at the beach mainly between May and November, are seasonal residents. Heerman's gulls are usually found in association with brown pelicans; both species feed mainly upon anchovies in nearshore areas during spring and early fall (USFWS 1990). Another common gull species is the mew gull, which is present mainly between October and April. These and other gulls are known for their diverse eating habits, and they depend in part upon the beach habitat for sustenance. In addition, shorebirds such as black oystercatcher, black-bellied and snowy plovers, whimbrel, sanderling, and marbled godwit forage along the intertidal and wave roll-out zone, probing beneath or picking at the sand surface for invertebrates or small crustaceans. The dry upper beach areas, where most construction work would take place, provide little nourishment for these shorebirds.

Gulls and shorebirds were selected as evaluation species for sandy beach habitat because of their non-consumptive value to the public (aesthetics, bird watching, etc.), their sensitivity to land-use changes in the area, and because of Service responsibilities for their management under the Migratory Bird Treaty Act. We have determined that the sandy beach habitat at Ocean Beach that would be impacted by the project provides high to medium values for these evaluation species. In addition, this habitat is relatively abundant along the coast. Therefore, we have determined that this habitat should have a mitigation planning goal of no net loss of habitat value while minimizing loss of in-kind habitat value (Resource Category 3).

The evaluation species chosen for dune habitats that would be impacted by the project is the common garter snake. The garter snake, which may be found during the warmer summer and fall months, uses the dunes for nesting and foraging. Dune habitat generally provides high value to the snake, and this habitat is now relatively scarce along the coast, due to erosion and loss of beach sand. Therefore, our mitigation planning goal for dune habitat that would be impacted by the project is for no net loss of in-kind habitat value (Resource Category 2).

General Mitigation Aspects

To minimize the adverse effects of sand dune nourishment on terrestrial species, sand placement should be done on a gradual, intermittent basis that allows optimal escape, relocation, and thus survival of sand-dwelling organisms. Very rapid and deep placements of large quantities of sand should generally be avoided. We recommend that not more that 12 inches vertical depth of sand be initially placed for the first 24-hour period. Also, sand grain size should be adequate to minimize erosion, while at the same time provide a substrate suitable for sand-dwelling organisms. The source of sand for the nourishment should be from an approved borrow source, and be free of any contaminants, either physical or chemical, that could affect benthos organisms in the beach areas. Also, the use of sand from a source which presently provides nesting or foraging habitat for significant fish and wildlife species (for example, bank swallows) should be avoided.

Additionally, beach nourishment should be accomplished when sensitive species are not in the area. Construction activities should generallyb be limited to late April through early July for Reaches 1 and 2, and September through March for Reach 3, because wintering plovers are known to occupy Reaches 1 and 2 in the winter, and bank swallows are nesting and active in Reach 3 in the spring and summer.

Planting of non-native grasses should be avoided, as that has been shown to eliminate native terrestrial invertebrates (Slobodchikoff 1977) and other wildlife species that depend on them for their sustenance. Any vegetation which is disturbed by sand placement activities should be restored to native sand dune habitat.

Adverse impacts to aquatic organisms should be avoided or minimized to the extent practicable. Much of the direct impact to the aquatic community could be reduced by the use of dredge material from a previously or ongoing project, rather than a new dredging effort implemented for this project. The initial and maintenance dredging should be timed to avoid the periods of peak organism use, particularly by fish and invertebrates. In general, impacts to these species can often be minimized by restricting work to the late summer and early fall months (late August to early November).

Specific Mitigation Aspects

We recommend that the following actions be implemented as part of the project at Ocean Beach. These general guidelines closely follow those implemented for

the Asilomar Dunes Restoration Project at Asilomar State Beach (Moss 1992). The Asilomar Project is one of the more successful, long-term dune restoration projects on the West Coast. A contractor that specializes in propagation and restoration of native sand dune plant species should be consulted prior to implementation of the final plan. All restoration work should be coordinated with the National Park Service.

1. Seed Collection. To help preserve and restore the genetic integrity of the local plant community, native plant seeds should be collected in the vicinity of the project area. Because of the low numbers of native species in the area, caution should be used to ensure that the seed source for the area is not depleted below a self-sustainable level. If this would be the case, seed should be obtained from a local nursery that specializes in the propagation of native plants.

2. Management of Exotic Species. European beach grass is abundant on the existing dunes at Ocean Beach. This species is highly aggressive, and tends to compete with native species. Although eradication of this species from the project area is not part of the proposed project, management will be necessary to ensure that this species does not invade into the restoration area and compete with native plantings. The most effective methods of management appear to be manual removal and herbicide treatment. Manual removal is preferred; if herbicides are used, caution must be used to avoid spraying native plants and particularly, sensitive species.

3. Dune Reconstruction and Stabilization. According to project information, sand would be brought onto the construction site by slurry pipe or by truck. In either case, dunes would be built from the existing dunes seaward using earth-moving equipment. Since young plantings or seeds would have a difficult time surviving on an active dune, the sand will need interim stabilization while the planted seeds or plants are becoming established. It is recommended that some type of matting be used to prevent sand erosion, particularly by wind, until plants become established (Pye 1990). We recommend either of two methods: hydromulching or planting straw clumps into the sand. Both methods have been found to be successful. A minimum of 2 years stabilization is usually needed (Moss 1992). The use of soil-seal, an artificial sealant, is not recommended as it has been found to repel water and inhibit plant growth at the Asilomar dune restoration site.

4. Revegetation. Species recommended for planting are listed in Table 1. Species composition should consist of species native to the area, that presently occur or historically occurred on the project site. Locally collected seeds should be propagated near the project site and the resulting container plants used in the revegetation effort. We recommend using container plants rather than seed because of the highly unstable conditions at the site. Use of seeds would likely result in a significant reduction in plant establishment and survival. Seeds would likely be transported by wind and covered by blowing sand. Plantings would be better suited to surviving these harsher conditions.

Irrigation should be used, but in a way that ensures that plantings do not become dependant on it. If not done carefully, irrigation could produce weed plants and cause plants to not establish an adequate root system (Jacob Sigg, pers. comm.).

Table 1. Plant species recommended by the California Native Plant Society, Yerba Buena Chapter (Jacob Sigg pers. comm.), for dune restoration in the project area.

Common Name	Scientific Name
Yellow sand verbena	Abronia latifolia
Pink sand verbena	Abronia breviflora
Coastal sagewort	Artemisia pycnocephala
Beachbur	Franseria chamissonis
Beach evening primrose	Camissonia cheiranthifolia
Dune grass	Elymus mollis
sea rocket	Cakile maritima
beach pea	Lathyrus littoralis
Beach strawberry	Fragaria chiloensis
Beach morning glory	Calystegia soldanella
Bush lupine	Lupinus arboreus
Silver lupine	Lupinus chamissonis

5. Restoration Protection. Measures should be taken to provide protection to the restoration area. These measures should include fencing and boardwalks to guide pedestrians away from the restored area, and educational signs posted to inform the public about the significance of the area and the importance of protection. Similar work has been done by the National Park Service at Baker Beach and could be used as a model for the Ocean Beach project.

CONCLUSIONS

The Fish and Wildlife Service supports the concept of restoring native sand dune habitat at Ocean Beach. However, we are concerned that the dune nourishment alternative may adversely impact habitat for the federally-listed threatened western snowy plover. As stated earlier, the effects of the project on this species will be addressed in our final FWCA Report, pending completion by the Corps of the appropriate Section 7 procedures, pursuant to the Endangered Species Act of 1973, as amended. In this regard, the Corps should proceed forthwith in the completion of appropriate BAs related to the project.

The Service's analyses indicate that the proposed Ocean Beach Storm Damage Reduction Project would generally only have some minor, mostly temporary adverse affects to beach habitat, its benthos, and aquatic resources, and be beneficial overall by the restoration of significant new areas of sand dune habitat. The project would also have a small, temporary adverse affect to vegetation on the seaward side of currently existing dunes where construction would take place.

However, over the long-term, sand placement and planting of native vegetation at Ocean Beach would contribute significantly to restoring native sand dune habitat that has become quite scarce along shorelines of the San Francisco Peninsula. Although the primary purpose of the project is sand stabilization, the incidental ecological values are also important. We commend the Corps for the selection of this particular alternative, which the Service recommended as

the least-damaging of four alternatives that were analyzed in the reconnaissance stage of project planning. However, if it is determined that the project would appreciably diminish the value of critical habitat of the western snowy plover, or otherwise affect this species, an alternative beach protection option may need to be developed. This could possibly be a combination of dune nourishment with other features incorporated to ensure avoidance of adverse impacts to this sensitive species.

A number of dune creation and stabilization projects have been attempted; a handful have been somewhat successful in terms of maintaining stable, vegetated dunes. These projects, however, deal primarily with inland dunes which are relatively stable, as opposed to the more mobile foredunes, such as the ones found at Ocean Beach. This, plus the relatively harsh wind and erosion conditions at Ocean Beach, may make stabilization of the dunes very difficult. The recommendations below and the guidelines outlined in the restoration plan are designed to maximize the chances of successful vegetative restoration at the dune nourishment sites, and to minimize the adverse impacts that could occur as a result of the project.

RECOMMENDATIONS

The following specific recommendations are intended to avoid or minimize adverse impacts of the dune nourishment alternative. The Service recommends that:

1. The final report of the Corps of Engineers include conservation and enhancement of fish and wildlife resources among the purposes for which this project is to be authorized.

2. The Corps complete, forthwith, its Section 7 requirements under the Act, so that the results of such may be effectively integrated into the Service's recommendations and final FWCA Report for the project.

3. The local sponsor of the project complete forthwith any consultation requirements with the California Department of Fish and Game required under the California Endangered Species Act relating to the State-listed threatened bank swallow, so that the results of such may be included in the Service's final FWCA Report.

4. To minimize adverse impacts to aquatic organisms, previously dredged material or an existing borrow site be used for sand dune nourishment, rather than initiating new dredging specifically for this project. In either case, only sand of the proper size, consistency, and quality should be used.

5. All phases of the vegetative restoration program be coordinated with National Park Service staff biologists to ensure that plantings are consistent with their biological objectives for Ocean Beach.

6. Created dunes be properly fenced to prevent foot traffic from entering the restoration sites. Also, interpretive signs signifying dune restoration should be erected within the fenced area.

7. Boardwalks be constructed between dunes to minimize traffic through the dune restoration area.

8. The Corps develop a detailed revegetation and remedial action plan for the project. The revegetation plan should be developed by an independent contractor familiar with native plant restoration, with input from the National Park Service, California Department of Fish and Game, California Native Plant Society, and the Service. Vegetative monitoring should be conducted during the first 10-year period, and subsequent periods, if needed.

9. During construction, construction areas be fenced or otherwise marked to exclude construction vehicles from encroaching into the intertidal zone.

10. The proposed project construction schedule, during which sand would actually be deposited on the beach, be restricted to late April through early July for Reaches 1 and 2, and September through March for Reach 3, to avoid or minimize adverse impacts to sensitive species. Both initial sand placement and maintenance placement should be carried out during these periods.

11. Sand be placed on the beach in small increments, as described earlier in this report, to minimize adverse impacts to beach fauna.

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APPENDIX A
PLANT AND ANIMAL SPECIES
LIKELY TO BE FOUND ON THE PROJECT AREA

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PLANT AND ANIMAL SPECIES LIKELY TO BE FOUND IN THE PROJECT AREA

PLANTS	SCIENTIFIC NAME
Native	
sea fig (iceplant)	*Mesembryanthemum chilense*
hotentot (iceplant)	*Mesembryanthemum edule*
European beach grass	*Ammophila arenaria*
dune grass	*Elymus mollis*
sand verbena	*Abronia latifolia*
beach pea	*Lathyrus latifolia*
Non-native	
sea rocket	*Cakile maritima*
hebe	*Hebe salicitolia*
Pittosporum	*Pittosporum repens*
Myoporum	*Myoporum laetum*
mirror plant	*Coprosma repens*
Monterey cypress	*Cupressus macrocarpa*

BIRDS	
red-throated loon	*Gavia stellata*
common loon	*Gavia immer*
Pacific loon	*Gavia arctica*
Clark's grebe	*Aechmophorus clarkii*
western grebe	*Aechmophorus occidentalis*
brown pelican	*Pelecanus occidentalis*
double-crested cormorant	*Phalacrocorax auritus*
Brandt's cormorant	*Phalacrocorax penicillatus*
pelagic cormorant	*Phalacrocorax pelagicus*
northern shoveler	*Anas clypeata*
greater scaup	*Aythya marila*
mallard	*Anas platyrhynchos*
common merganser	*Merganser merganser*
red-breasted merganser	*Mergus serrator*
hooded merganser	*Lophodytes cucullatus*
black scoter	*Melanitta nigra*
white-winged scoter	*Melanitta fusca*
surf scoter	*Melanitta perspicillata*
American kestrel	*Falco sparverius*
black oystercatcher	*Haematopus bachmani*
snowy plover	*Charadrius alexandrinus*
killdeer	*Chradrius vociferus*
black-bellied plover	*Pluvialis squatarola*
marbled godwit	*Limosa fedoa*
whimbrel	*Numenius phaeopus*
long-billed curlew	*Numenius americanus*

willet	*Catoptrophorus semipalmatus*
sanderling	*Calidris alba*
parasitic yaeger	*Stercorarius parasiticus*
pomarine jaeger	*Stercorarius pomarinus*
Heerman's gull	*Larus heermani*
Bonaparte's gull	*Larus philadelphia*
mew gull	*Larus canus*
herring gull	*Larus argentatus*
California gull	*Larus californicus*
glaucous gull	*Larus hyberboreus*
western gull	*Larus occidentalis*
Forster's tern	*Sterna forsteri*
elegant tern	*Sterna elegans*
Caspian tern	*Sterna caspia*
common murre	*Uria aalge*
pigeon guillemot	*Ceppus columba*
marbled murrelet	*Brachy marmoratus*
rock dove	*Columba livia*
belted kingfisher	*Ceryle alcyon*
bank swallow	*Riparia riparia*
rough-winged swallow	*Stelgidopteryx serripennis*
barn swallow	*Hirundo rustica*
American crow	*Corvus brachyrhynchos*
water pipit	*Anthus spinoletta*
Brewer's blackbird	*Euphagus cyanocephalus*
house finch	*Carpodacus mexicanus*

AMPHIBIANS, REPTILES, AND MAMMALS

western toad	*Bufo boreas*
western fence lizard	*Scleropus occidentalis*
gopher snake	*Pituophis melanoleucas catenifer*
common garter snake	*Thamnophis sirtalis*
house mouse	*Peromyscus maniculatus*
California ground squirrel	*Citellus beecheyi*
California grey squirrel	*Sciurus griseus*

APPENDIX B
FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7 (a) and (c) OF THE ENDANGERED SPECIES ACT

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7 (a) and (c) OF THE ENDANGERED SPECIES ACT

SECTION 7(a) Consultation/Conference

Requires: 1) Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species 2) Consultation with FWS when a Federal action may affect a listed endangered of threatened species to insure that any action authorized, funded or carried out by a Federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the Federal agency after determining the action may affect a listed species; and 3) Conference with FWS when a Federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat.

SECTION 7(c) Biological Assessment--Major Construction Activity[1]

Requires Federal agencies or their designees to prepare a Biological Assessment (BA) for major construction activities. The BA analyzes the effects of the action[2] on listed and proposed species. The process begins with a Federal agency requesting from FWS a list of proposed and listed threatened and endangered species. The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the list, the accuracy of the species list should be informally verified with our Service. No irreversible commitment of resources is to be made during the BA process which would foreclose reasonable and prudent alternatives to protect endangered species. Planning, design, and administrative actions may proceed; however, no construction may begin.

We recommend the following for inclusion in the BA: an on-site inspection of the area affected by the proposal which may include a detailed survey of the area to determine if the species or suitable habitat are present; a review of literature and scientific data to determine species' distribution, habitat needs, and other biological requirements, interviews with experts, including those within FWS, State conservation departments, universities and others who may have data not yet published in scientific literature; and analysis of the effects of the proposal on the species in terms of individuals and populations, including consideration of indirect effects of the proposal on the species and its habitat; an analysis of alternative actions considered. The BA should document the results, including a discussion of study methods used, any problems encountered, and other relevant information. The BA should conclude whether or not a listed or proposed species will be affected. Upon completion, the BA should be forwarded to our office.

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1 A construction project (or other undertaking having similar physical impacts) which is a major Federal action significantly affecting the quality of the human environment as referred to in NEPA (42 USC 4332 (2)c).

2 "Effect of the action" refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action.

APPENDIX C
ENDANGERED SPECIES CONSULTATION

United States Department of the Interior

TAKE PRIDE IN AMERICA

FISH AND WILDLIFE SERVICE
Ecological Services
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

In Reply Refer To:
1-1-93-SP-510

March 31, 1993

Mr. William C. Angeloni
Chief, Planning and Engineering Division
Army Corps of Engineers - San Francisco
211 Main Street
San Francisco, California 94105-1905

Subject: Updated Species List for the Ocean Beach Storm Damage Reduction Study, City and County of San Francisco, California

Dear Mr. Angeloni:

As requested by your memo from your agency dated January 27, 1993, you will find enclosed an updated list of the proposed and listed endangered and threatened species that may be present in the subject project area. (See Enclosure A.) This list fulfills the requirement of the Fish and Wildlife Service (Service) to provide a species list pursuant to Section 7(c) of the Endangered Species Act, as amended, (Act).

Pertinent information concerning the listed species life history and distribution, and a discussion of the responsibilities of federal agencies under Section 7(c) of the Act were provided for those species addressed in response to your initial request for a species list. Attached is information concerning those listed species not previously addressed.

Formal consultation, pursuant to 50 CFR § 402.14, should be initiated if you determine that a listed species may be affected by the proposed project. If you determine that a proposed species may be adversely affected, you should consider requesting a conference with our office pursuant to 50 CFR § 402.10. Informal consultation may be utilized prior to a written request for formal consultation to exchange information and resolve conflicts with respect to a listed species. If a biological assessment is required, and it is not initiated within 90 days of your receipt of this letter, you should informally verify the accuracy of this list with our office.

Also, for your consideration, we have included a list of the candidate species that may be present in the project area. (See Enclosure A.) These species are currently being reviewed by the Service and are under consideration for possible listing as endangered or threatened. Candidate species have no protection under the Endangered Species Act, but are included for your consideration as it is possible that one or more of these candidates could be proposed and listed before the subject project is completed. Should the biological assessment reveal that candidate species may be adversely affected, you may wish to contact our office for technical assistance. One of the potential benefits from such technical assistance is that by exploring alternatives early in the planning process, it may be possible to avoid conflicts that could otherwise develop, should a candidate species become listed before the project is completed.

Please contact Laurie Stuart Simons of this office at (916) 978-4866 if you have any questions regarding the enclosed list or your responsibilities under the Endangered Species Act. For questions concerning the threatened winter-run chinook salmon, please contact Jim Lecky, Endangered Species Coordinator, at the National Marine Fisheries Service, Southwest Region, 501 West Ocean Boulevard, Suite 4200, Long Beach California 90802-4213, or call him at (310) 980-4015.

Sincerely,

for Wayne S. White
Field Supervisor

Enclosures

cc: FWS-SFO (CE Projects, Rich DeHaven), Sacramento, CA
National Marine Fisheries Service, Southwest Region, Attn: Jim Lecky,
501 West Ocean Boulevard, Suite 4200, Long Beach California 90802-4213

ENCLOSURE A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR IN THE AREA OF THE PROPOSED OCEAN BEACH STORM DAMAGE REDUCTION STUDY, CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA (1-1-93-SP-510, MARCH 31, 1993)

Listed Species

Fish

winter-run chinook salmon, *Oncorhynchus tshawytscha* (T)

Birds

western snowy plover, coastal population, *Charadrius alexandrinus nivosus* (T)

Plants

Presidio manzanita, *Arctostaphylos hookeri* var. *ravenii* (E)
beach layia, *Layia carnosa* (E)

Proposed Species

Fish

tidewater goby, *Euclyclogobius newberryi* (PE)

Plants

swamp sandwort, *Arenaria paludicola* (PE)
Presidio clarkia, *Clarkia franciscana* (PE)
Marin dwarf-flax, *Hesperolinon congestum* (PT)

Candidate Species

Fish

green sturgeon, *Acipenser medirostris* (2R)
longfin smelt, *Spirinchus thaleichthys* (2R•)

Amphibians

California tiger salamander, *Ambystoma californiense* (2•)
California red-legged frog, *Rana aurora draytonii* (1•)
foothill yellow-legged frog, *Rana boylei* (2)

Reptiles

southwestern pond turtle, *Clemmys marmorata pallida* (1•)

Mammals

San Francisco dusky-footed woodrat, *Neotoma fuscipes annectens* (2)
Pacific western big-eared bat, *Plecotus townsendii townsendii* (2)
greater western mastiff-bat, *Eumops perotis californicus* (2)

Invertebrates

globose dune beetle, *Coelus globosus* (2)
bumblebee scarab beetle, *Lichnanthe ursina* (2)

Plants

Franciscan manzanita, *Arctostaphylos hookeri* ssp. *franciscana* (1**)
San Francisco gumplant, *Grindelia maritima* (2)
bay matchweed, *Gutierrezia californica* (2R)
Diablo rock-rose, *Helianthella castanea* (2)

Plants continued

- wedge-leaved horkelia, *Horkelia cuneata* ssp. *sericea* (2)
- San Francisco lessingia, *Lessingia germanorum* var. *germanorum* (1)
- San Francisco owl's-clover, *Orthocarpus floribundus* (2)
- San Francisco popcornflower, *Plagiobothrys diffusus* (2*)
- adobe sanicle, *Sanicula maritima* (2)
- Marin checkermallow, *Sidalcea hickmanii* ssp. *viridis* (2)
- Mission Delores campion, *Silene verecunda* ssp. *verecunda* (2)

(E)--Endangered (T)--Threatened (P)--Proposed (CH)--Critical Habitat
(1)--Category 1: Taxa for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.
(2)--Category 2: Taxa for which existing information indicated may warrant listing, but for which substantial biological information to support a proposed rule is lacking.
(1R)-Recommended for Category 1 status.
(2R)-Recommended for Category 2 status.
(•)--Listing petitioned.
(*)--Possibly extinct.

APPENDIX D
HABITAT ANALYSIS

APPENDIX D
HABITAT ANALYSIS

Habitat Quantity

Sand dunes would be constructed and vegetation would be planted during the first year; dunes would continue to erode at the estimated 2-5 feet per year rate. Nourishment would occur again at the next 10-year interval. Acreage lost over time due to erosion was calculated for each reach using the estimated 5 foot rate for Reach 1 and 2 foot rate for Reaches 2 and 3. The erosion rate is the same as without the project. Acreage of created dune habitat lost for each reach over each 10 year interval is as follows:

Reach 1: 5 feet lost per year x 870 lineal feet = .10 acre

.10 acre x 10 (yrs) = 1 acre

= 1 acre lost per 10 year interval.

Reach 2: 2 feet lost per year x 700 lineal feet = .03 acre

.03 acre x 10 (yrs) = .32 acre

= .32 acre lost per 10 year interval.

Reach 3: 2 feet lost per year x 2375 lineal feet = .11 acre

.11 x 10 (yrs) = 1.1 acres

= 1.1 acres lost per 10 year interval.

Habitat Quality

Relative to other sand dune habitat on the San Francisco peninsula, we estimate that existing sand dune habitat at Ocean Beach is rated at a quality of .3, on a scale of 0.0-1.0. This rating is based on habitat characteristics related to plant species composition and richness and on level of habitat disturbance. Vegetation at existing Ocean Beach dunes is characterized largely by monotypic stands of European beach grass with scatterings of native species such as yellow sand verbena, and sea rocket, a non-native, yet less invasive species than European beach grass. This composition of species has resulted in 1) the loss of native plant species and the associated wildlife species that depend on them--invertebrates, amphibians, reptiles, birds, and small mammals, 2) high vegetation density, which promotes foot traffic and other human use of the dunes (tall dense cover) and 3) greater cover for predator species which deters use of the dunes by shorebirds and other species.

On a scale of 0.0-1.0, we estimate that created dunes would have a quality value of .9. This value is based on the assumption that created dunes would possess characteristics similar to the more native and pristine sand dune habitat that once existed at Ocean Beach, and that existing habitat values would remain relatively stable.

We anticipate that the re-created dune habitat would exhibit high species richness, composed primarily of species native to the Ocean Beach area. We also assume that educational and protective components, such as educational signs, fencing, and boardwalks, would be included in the restoration plan.

These actions would help minimize human use and disturbance of the restored areas, and contribute to ensuring maximum habitat values at the restoration sites.

Overall, we estimate that the new dune complex, which would be composed of the existing dunes plus created dunes, would have a quality value of .6, the average of the two. Maximum habitat values would be reached the third year after each nourishment.

An Evaluation of Dune Nourishment and Restoration Projects

Submitted to :
Len Madalon
U.S. Army Corps of Engineers
San Francisco

Submitted By: Peter J. Elkan
May 31, 1994

ABSTRACT

The purpose of this research was to document the performance of dune restoration projects similar to that proposed at Ocean Beach. San Francisco. A literature review was performed to determine the success of dune nourishment and restoration projects undertaken along the coastline of United States. Projects located on the Atlantic and Pacific coasts were reviewed. Due to the limited amount of monitoring studies, interviews were performed to document dune restoration projects. Three types of dune nourishment projects were reviewed including: large scale beach and dune nourishment, experimental dune stabilization, and dune revegetation. A site specific evaluation was performed for each restoration project.

INTRODUCTION

The degree of success of a restoration project is difficult to estimate. The performance of a beach restoration can not be measured based upon the percent of sand accumulated alone. Economic benefits of coastal protection. extent of revegetation , and effectiveness of dune stabilization must all be considered. Because of limited monitoring, it is not feasible to perform a comprehensive evaluation incorporating all these factors. A combination of factors was used to document the performance of projects using the available data.

DUNE NOURISHMENT SUCCESS

I. Dune and Beach Nourishment

Several nourishment projects that have been closely monitored are found on the Atlantic coast. Miami Beach, FL, Ocean Beach, MD, and Hunting ,SC are sites where a combination of beach and dune restoration projects were implemented to protect the coastline. The success of each project was determined by examining the economic benefits gained at each site. Dune nourishment and revegetation similar to that proposed at Ocean Beach, CA were pivotal in the success of both the Miami Beach, and Ocean Beach sites.

The Miami Beach restoration, completed in 1987, required an initial fill of 15.5 million cubic yards. An additional 680,000 cy has been placed for renourishment. Average annual costs of the project of $2.7 million are outweighed by the estimated $18 million in annual benefits (recreation, prevention of storm damage, hurricane protection, and enhancement of property damage) providing a benefit-cost ratio of 6.5 to 1 (Wiegel, 1994). The site withstood the severe impact of Hurricane Andrew in 1992, incurring limited damage. The planting of sea oats to restore the natural vegetation has stabilized the dunes. The revegetation has prevented dune erosion and overtopping from occurring.

The large scale beach and dune restoration in Ocean City, Maryland has proven successful in protecting the coastline. At Ocean Beach a fill of 6.5 million cy was placed over a length of 7 miles. Construction was completed in 1989 with a total cost of $58.4 million (Stauble and Grosskopf, 1993). In October 1991 and January 1992 storms impacted the coastline with surge levels as high as 6.6 feet (2.01m). The project is estimated to have prevented approximately $93 million in flooding damages from incurring, and a potential $500 million in revenues produced the following summer (Stauble and Grosskopf, 1993). The dunes have remained in place with most of the sediment loss occurring at the beach berm.

Hunting Island State Park, South Carolina is a site where a series of nourishment projects had met with limited success. Alongshore transport occurring at this particular site has influenced the success of nourishment. From 1968 to 1980 dune and beach restoration attempts involved the placement of over 3.5 million cy at $4.2

million. In 1991 755,000 cy of fill was placed along a 7,500 ft stretch of coastline. The final cost of the project was approximately $2.92 million After two years of monitoring only 41% of the fill remained, with an estimated usable life of 1.5 years.

(Kana and Andrassy, 1993)

II. Dune Restoration Research Projects

Pilot studies undertaken by the U.S. Army Corps of Engineers provide long-term monitoring data of dune restoration and stabilization. Sand accumulation over the monitoring period is used to evaluate the success of each pilot project. Factors influencing the success of dune stabilization include the species of dune grass, method of construction (mats, supporting fences, etc.), and environmental factors including wind and wave climate. Table 1 is a summary of the pilot studies performed at four different locations.

Table 1. Comparison of annual accretion and dune growth rates.
(Knutson, 1980)

Location	*Crest Growth (m)*	*Sand Accumulation (m^3/m)*	*Monitoring Period (yrs)*	*Vegetation*
Ocracoke Island, North Carolina	0.18	8.4	10	Sea Oats
San Padre Island, Texas	0.46	10.8	3	Bitter Panicum Sea Oats
Nauset Beach, Cape Cod , Mass.	0.25	8.3	7	American Beachgrass
Clatsop Plains, Oregon	0.27	13.7	30	European Beachgrass

Revegetation has increased the size of dunes at each site. The San Padre Island restoration demonstrated the value of dune restoration as a means of coastal protection. Results of a post hurricane survey in the region 1983 indicate that the restored dunes provided storm protection, while several of the dunes without vegetation were breached during this event.

The Nauset Beach projrct evaluated several alternatives of planting American Beachgrass, a species that is native to Ocean Beach, CA. Variation in spacing of plants at 30cm, 60cm, and 90cm were performed. Each planting produced a significant increase of sand elevation over a seven year growing season. The dunes with plants spaced at 30cm, 60cm, and 90cm achieved an increase in crest elevation of 1.8m, 1.6m, and 2.0m respectively (Knutson, 1980).

Clatsop Plains, OR maintains an environment similar to that found at Ocean Beach, CA. This site provides the longest history of monitoring over a period of 30 years. European beachgrass was planted to stabilize the dunes in 1935. The project was successful in stabilizing the dune system, providing an average annual accumulation of $13.7m^3$/ linear m. Dunes have elevated from 6m to 6.3m above the beach berm over the 30 yr period. By planting a foreign species, the project failed to restore the natural dune ecosystem (Meyer and Chester,1977).

III. California Dune Stabilization and Revegetation

Several dune restoration projects were undertaken in Monterey County, CA in the past ten years. Sites of dune restoration located include Marina State Beach, Asilomar State Beach, Monterey Dunes Colony, Spanish Bay Restoration, and Sunset State Beach. Because of the limited documentation of these projects, interviews with project managers were conducted to document the degree of success of each restoration effort. The success of each project was determined based on the goals of restoration for the particular site. The results of this study are summarized in Table 2.

Table 2. Evaluation of Dune Restoration Projects
Monterey County, CA

Location	*Area (acres)*	*Date*	*Stabilization*	*Revegetation*
Asilomar State Beach	65	1984	X	X-iceplant is still a dominating species
Marina State Beach	31	1986	X	X- iceplant and European beachgrass are abundant
Spanish Bay (Pebble Beach Co. Golf Course)	45	1985 -	X	not successful in growing native dune species
Monterey Dunes Colony (Castroville,CA)	100	1987-88	X	X-most successful in removing foreign species
Sunset State Beach	17	1986	X	primary goal of this project was stabilization

X- indicates that the majority of people interviewed agree that the project is successful
See references for a list of those persons interviewed.

Project success is dependent upon the primary goal of restoration. Each project examined has proven to be effective in stabilizing the dunes. The common shortcoming to the restoration projects is the difficulty in restoring endemic plant species.

The Asilomar Beach, Marina Beach, and the Monterey Bay Colony projects have all proven to be successful in achieving the restoration objectives (Moss,1994 and Gray,1994). The three sites harbor a diversity of native plant species. There were two common factors that were key in promoting the success of these projects. The irrigation that is essential to germinate plant growth, and protection of the dune plants from human impact.

The one project that has been determined unsuccessful is that undertaken at Spanish Bay. There are many complications to this project which have hindered the restoration efforts. The site is located on a golf course where the sensitive dune plants are subject to trampling by passers-by. A second complication was the selection of a soil fill that is not able to support the targeted dune species (Moss,1994, Gray,1994, Pickart,1994). The fill design was a loamy to sandy soil substrate, with an overlying sand layer. During construction the sand was mixed into the substrate. The clayey soil inhibited growth of dune vegetation. A pure sand fill would have promoted the optimum success of the dune revegetation project (Guinon,1988).

CONCLUSIONS

Dune nourishment has proven to be an effective means of coastal protection. The examples discussed demonstrate that with proper research and monitoring there is a high rate of success of restoration projects. Due to the limited monitoring data, it was necessary to rely on qualitative evaluations to document project performance. For future reference it is suggested that monitoring projects be implemented to obtain a quantitative measurement of the restoration sites.

APPENDIX C3

State Historic Properties Survey Report

SAN FRANCISCO OCEAN BEACH STORM DAMAGE REDUCTION STUDY
HISTORIC PROPERTIES SURVEY

prepared for

U. S. Army Corps of Engineers
San Francisco District
Environmental Branch
211 Main Street
San Francisco California 94105

prepared by
Michael Jablonowski
Project Coordinator

Principal Investigator
Adrian Praetzellis, Ph.D., SOPA

The Anthropological Studies Center
Sonoma State University
Foundation Center 300
Rohnert Park California 94928

February 1995

CONTENTS

SAN FRANCISCO OCEAN BEACH STORM DAMAGE REDUCTION STUDY
HISTORIC PROPERTIES SURVEY

Introduction

The U.S. Army Corps of Engineers San Francisco District and the City of San Francisco are conducting a study to minimize storm damage to the dunes, the Great Highway, and adjacent properties to Ocean Beach in San Francisco, California. As a part of a Corps of Engineers (COE) sociocultural research contract with Sonoma State University's Anthropological Studies Center (ASC), the ASC in conjunction with the National Park Service Submerged Cultural Resources Unit (SCRU) conducted a remote sensing archaeological survey for three portions of Ocean Beach within the National Park Service Golden Gate National Recreation Area (GGNRA).

Based on the findings and recommendations of a testing plan prepared for COE (Historic Properties Testing Plan, San Francisco Ocean Beach, Jablonowski, Lape, and Muir, 1993), a field investigation of the project area was conducted through a cooperative agreement between COE, the City of San Francisco, SCRU, GGNRA and the ASC. The historic properties survey was requested by Dr. Richard Lerner, COE San Francisco District for compliance with Section 106 of the National Historic Preservation Act. As a result of the agreement, SCRU conducted the survey for all of Ocean Beach within GGNRA boundaries.

The proposed project will involve the placement of additional sand on the face of the dunes. Impacts from construction equipment used in the stabilization project are not expected to exceed six feet in three locations totaling approximately one mile in length. This report is limited to discussion of findings within COE project boundaries and a discussion of the King Philip/Reporter wreck, a Registered Historical Landmark that lies near to, but outside the project area.

The purposes of the COE field study were (1) to identify exact locations of magnetic anomalies that may represent shipwrecks within the proposed project areas; (2) to conduct subsurface field studies to identify whether or not such anomalies are of shipwreck origin; (3) to make preliminary evaluations for all identified shipwreck materials as to their eligibility for inclusion in the National Register of Historic Places; and (4) to determine whether potential National Register properties might be affected by the proposed project.

Potential shipwreck locations were identified through a terrestrial magnetometer survey of the beach area. The survey was conducted by SCRU and ASC staff in February 1995. Thirty-eight anomalies were identified in the COE project area as a result of the survey, and 19 of these locations were hand-excavated and augured by ASC staff and volunteers in an attempt to expose the features causing the anomalies. None of the features was located within 6 feet of the current surface elevation of the beach. Recommendations for additional study are presented at the end of this report.

Study Area Description

Ocean Beach is situated within the Golden Gate National Recreation Area and forms the westernmost boundary of the city of San Francisco (Figure 1 P. 11). The beach is approximately 3 miles in length, running from below the Cliff House in the Richmond District in the north to the San Francisco/San Mateo County line at its southern boundary. The littoral zone is characterized by heavy surf and strong currents. The beach has a shallow gradient that is undercut in places by the surf, especially during winter storms. It is composed of light, fine grained sand that shifts continually as a result of current and wave action. At mean low tide, the beach is approximately 250 feet wide in the northern portion, narrowing to approximately 100 feet or less below the bluffs at the foot of Sloat Boulevard. Concrete seawalls and reconstructed sand dunes form the eastern boundary in the northern portion near Golden Gate Park and the Sunset District. Eroding bluffs and cliffs form the boundary in the southern portion near the San Francisco Zoo and Fort Funston.

Climate for San Francisco is characterized as mediterranean, with mild wet winters and cool dry summers. Annual coastal temperatures do not vary greatly between summer and winter, with average daytime beach temperatures of about 50 degrees fahrenheit. The beach is exposed to the open ocean and both strong winds and fog are common throughout the year. Despite these unfavorable conditions, the proximity of the beach to city neighborhoods and Golden Gate Park results in heavy public use.

The study area, as originally defined by COE in 1993, consisted of three reaches: Reach One between Moraga and Ortega streets, Reach Two between Taravel and Ulloa, and Reach Three from Wawona to the southern boundary of Fleishacker Zoo for a combined length of approximately 2,000 feet. Study area width extends from the westerly toe of the existing dunes to 20 feet eastward and 150 feet seaward. The depth of the original study area was 20 feet. The 1993 study area was the basis for the **Historic Resources Testing Plan** prepared by ASC.

In January 1995 COE defined the Area of Potential Effect (APE) as consisting of two reaches with a combined length of approximately 6,500 feet and an additional 300-foot section midway between Rivera and Taraval streets. Reach One extends from the southern end of the concrete seawall beginning at Lincoln Way southward to a point approximately midway between Moraga and Noriega streets for a length of 3,500 feet. Reach Two extends from Wawona Street southward for approximately 3,000 feet to a point near the San Francisco Municipal Sewage Treatment Plant on the Great Highway Extension. Width of the APE extends approximately 130 feet westward from the toe of the dune or bluff, and the depth of the APE was reduced to 6 feet.

During the field survey, COE civil engineers requested an expansion to include the dunes between Lincoln Way and Noriega Street (Reach One) eastward to the Great Highway. Steep slopes and vegetation planted to control erosion prevented vehicular access to this expansion. These limitations would have required a pedestrian survey which, in turn, would have required additional equipment and conversion of existing

instruments. As a result of the limitations and project time constraints, the dune area was not included in the study.

Background Research

Research previously conducted by ASC (Jablonowski 1993) indicated twenty-eight reported wrecks within the general vicinity of the project area on Ocean Beach. Nine of these were reported wrecked within or near the APE boundaries. Wreck dates range from 1851 to 1902. Two of the wrecks, the King Philip and Reporter, have been located by previous archaeological studies in an area south of Reach One outside the current APE. The King Philip/Reporter wrecks are listed together in the National Register of Historic Places as a Registered National Historic Landmark. The wrecks are considered by the recorders to be the most intact remains of an American medium clipper in the continental United States. Since a number of shipwrecks occurred off Ocean Beach the area has been subject to many earlier historical and archaeological studies (see references P. 9 & 10).

Field Methods

A terrestrial magnetometer survey was conducted by SCRU and ASC staff under the direction of Larry Murphy, SCRU Senior Archeologist, for the entire 3-mile length of Ocean Beach within the Golden Gate National Recreation Area. The work was conducted over a period of five days in February 1995. A John Deere "Gator" 6x4 All Terrain Vehicle (ATV) was used as the tow vehicle for a small utility trailer and a sled behind the trailer. A laptop computer was mounted in the cab of the ATV and used to record and integrate sensing and positioning data. Four 12-volt car batteries provided the power source for the computer and the positioning and sensing equipment.

The remote-sensing and global-positioning units were mounted on a plastic sled constructed of 4 inch diameter PVC plastic drain pipe which was towed approximately 30 feet behind the trailer. This distance was considered sufficient to limit magnetic interference from the tow vehicle.

A Geometrics Proton Procession magnetometer Model 880 was used initially, but was later replaced with a prototype currently under testing by Geometrics. The prototype G-858 cesium magnetometer is more sensitive than previous models and can detect smaller anomalies at greater distances. It can also provide location readings at a much quicker rate than previous models. Readings were taken at a rate of one reading every two seconds for the duration of the survey although the G-858 is capable of rates up to ten times per second. The two second rate was selected to approximate global positioning system readings occurring at one and one-half second intervals.

Two GPS units, both with a 100 waystation capacity, were used to establish anomaly coordinates. A Trimble T4000 unit was used in conjunction with the magnetometer and a handheld Trimble Pathfinder unit was used to relocate waypoints for

attempted exposures. Both units were integrated with a DCI differential correction receiver to provide submeter accuracy.

The beach was surveyed in 3-meter-wide transects from the toe of the dune or bluff to below the mean low-tide mark. Transects were initially positioned by GPS but experience showed the same results could be obtained by aligning with the vehicle tracks of the previous transect. Tides of -0.5 feet msl occurred during the latter half of the survey week providing the opportunity to extend the transects farther seaward than would have been possible during normal low tides.

Once anomaly locations were identified (see Findings, below) samples were selected for exposure in order to determine whether anomalies were within 6 feet of the surface, the depth of the APE as defined by COE and to determine whether the features were of shipwreck origin. Nineteen locations were hand-excavated. These locations are shown in bold-face type in Table 1.

Once the position of the anomaly had been relocated with the Pathfinder GPS, 3-foot square holes were dug in the sand with shovels to a depth of approximately 4 feet--the point at which the sidewall of a pit usually began to collapse. Exposure attempts in locations closer to the surfline were abandoned at the depth where seawater was encountered--usually within 1 foot or less. In the drier landward locations, a minimum of four auger holes were dug at the bottom of the pit to sample an additional 2 to 3 feet. When maximum depth was obtained, the bottom of the pit was "swept" with a metal detector.

Findings

Thirty-eight magnetic anomaly locations were identified within the COE study area as a result of the survey. A map of all anomalies located within the GGNRA boundaries of Ocean Beach will be submitted by SCRU to the GGNRA Resource Management and Planning Office, Fort Mason, San Francisco.

The COE study areas were divided into three locational blocks: GOGA001, GOGA002 and GOGA003. Twenty-four anomalies were identified in GOGA001, six in GOGA002 and eight in GOGA003.

Locations of all waypoint coordinates are given in NAD 83 UTM Zone 0010 (meters) and translated to NAD 27 State Plane - CA III (meters), the system used on COE project maps; translations were provided by the U.S. Army Topographic Engineering Center. The coordinates and their translations are listed in Table 1; bold faced type indicates locations at which exposures were attempted.

Anomaly Location

Table 1

Anomaly Number	NAD 83 UTM m	NAD 27 State Plane
BLOCK GOGA001		
B001-001*	4179494N 543038E	465673.07379N 141898.19842E
B001-002	4179481N 543031E	465631.03807N 1418884.09498E
B001-003	4179472N 543038E	465600.89829N 1418906.26989E
B001-004	4179448N 543055E	465520.67161N 1418959.93540E
B001-005	4179435N 543063E	465477.32138N 1418985.04021E
B001-006	4179340N 543056E	465166.26792N 1418953.74867E
B001-007	4179238N 543086E	464829.00707N 1419043.22388E
B001-008	4179186N 543066E	464660.16313N 1418973.05461E
B001-009	4179164N 543054E	4645893.03924N 1418931.75951E
B001-010	4179143N 543089E	464517.07728N 1419044.73790E
B001-011	4179139N 543084E	464504.39263N 1419027.98452E
B001-012	4179109N 543096E	464404.91990N 1419064.72134E
B001-013	4179081N 543104E	464312.35912N 1419088.51129E
B001-014	4179050N 543082E	464212.58522N 1419013.62177E
B001-015	4179041N 543082E	464183.05889N 14197012.83285E
B001-016	4179027N 543327E	464115.65886N 1419815.34017E
B001-017	4179007N 543104E	464069.58701N 1419082.02454E
B001-018	4178992N 543109E	464019.93829N 1419097.11241E
B001-019	4178696N 543152E	463045.08168N 1419212.22924E
B001-020	4178628N 543160E	462821.29275N 1419232.51292E

Anomaly Number	NAD 83 UTM m	NAD 27 State Plane
BLOCK GOGA001 (continued)		
B001-021	4178573N 543172E	462639.80244N 1419267.05836E
B001-022	4178483N 543148E	462346.64226N 1419180.43605E
B001-023	4178474N 543166E	462315.53855N 1419238.69702E
B001-024	4178468N 543210E	462291.99851N 1419382.51524E
BLOCK GOGA002		
B002-001	4177606N 543295E	459456.56510N 1419585.86343E
B002-002	4177516N 543300E	459160.86079N 1419594.38678E
B002-003	4177498N 543303E	459101.54467N 1419602.65255E
B002-004	4177464N 543305E	458989.82441N 1419606.23700E
B002-005	4177430N 543306E	458878.19179N 1419606.54090E
B002-006	4177298N 543316E	458444.25846N 1419627.79003E
BLOCK GOGA003		
B003-001	4175810N 543419E	453554.98868N 1419836.73267E
B003-002	4175825N 543419E	453602.71006N 1419836.73267E
B003-003	4175763N 543427E	453398.60348N 1419857.54946E
B003-004	4175739N 543378E	453324.15950N 1419694.70129E
B003-005	4175760N 543410E	453390.25092N 1419801.51742E
B003-006	4175745N 543395E	453342.35427N 1419750.99597E
B003-007	4176512N 543330E	455864.37387N 1419604.90610E
B003-008	4176475N 543325E	455743.42480N 1419585.26417E

*Boldspace indicates locations of attempted anomaly exposure by hand excavation.

Samples from each block were selected for exposure in order to determine whether anomalies were within 6 feet of the surface the depth of the APE as defined by COE and to determine whether the features were of shipwreck origin. Nineteen locations were hand- excavated. These locations are shown in bold-face type in Table 1. SCRU recommended the locations to be excavated based on anomaly size, location, and proximity to adjacent anomalies under the recommendations made by SCRU.

No shipwreck remains were identified within the 1995 COE study area. The King Philip/Reporter wreck, a recorded historic archaeological site (CA-SFR-108H) and a Registered National Historic Landmark (86001014) is located near the project area. According to the archaeological site record, the remains of both vessels were located on the beach at mean low tide midway between Noriega and Ortega streets and approximately 120 meters south of the southern boundary of Reach A. UTM coordinates provided on the site record are incorrect, placing the wreck inland, east of the Great Highway. The photographs taken in 1983 provided by Stephan A. Haller, GGNRA Park Historian, indicate that remains of the vessels could be seen on the beach in the tidal zone.

The location, however, did evidence several anomalies that may represent the wreck (Larry Murphy 1995, pers. comm.). During the field study the described location of the King Philip/Reporter wreck was inspected at a -0.5 tide when the beach surface was above water for a distance of approximately 300 meters west of the Great Highway; this area was intensively inspected for evidence of timbers or depressions in the beach surface that might represent the wreck site. In addition to the visual inspection, a metal detector was used in an attempt to locate fastenings or chains. Visual inspection and the metal detector failed to identify any portion of the wreck. No attempt was made to expose features. ASC and SCRU staff believe the wreck had been reburied by deposition of sand from natural beach movement.

Recommendations

When the **San Francisco Ocean Beach Storm Damage Reduction Study** is determined to be an undertaking under Section 106, the lead agency shall consult with the California State Historic Preservation Office under **36 CFR 800**.

1. Prior to construction activity, an attempt should be made to relocate the King Philip/Reporter wreck site and obtain corrected UTM waypoints for the location. The purpose of the attempted relocation would be to insure that the location and an appropriate buffer zone would be established to prevent vehicular access during construction.

2. Beach elevations can vary significantly from year to year as a result of wave action and shifting sands. Due to the dynamic nature of the beach environment, any of the identified anomalies detected by the magnetometer survey lying within the COE Area of Potential Effect for the proposed project should be reinvestigated prior to commencement of work. Exposure attempts at anomaly locations within the APE may be best effected

by mechanical equipment such as a backhoe. Shoring equipment should also be on hand to allow full examination of any finds.

3. There is a remote possibility that shipwreck remains or other buried cultural materials may be encountered during project construction in areas where anomalies were not detected. Materials might include copper fastenings or sheathing, wood timbers, or other similar nonmagnetic material and rock ballast. All work in the area should be halted until a qualified archaeologist can evaluate the finds.

Literature Reviewed

In addition to the archaeological maps and site records on file at the Northwest Information Center of the California Archaeological Inventory, Sonoma State University, the following literature was reviewed:

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1993 *National Register of Historic Places Index by Property Location: Listed Properties (Computer Listing 1966 through 31 July 1993),* National Park Service, United States Department of the Interior, Washington, DC.

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1987 *Technologies for Underwater Archaeology and Maritime Preservation-Background Paper,* OTA-BP-E-37, Y, DC.

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APPENDIX C4

Social Environment Study Report

OCEAN BEACH
SOCIAL ENVIRONMENT STUDY

FOR THE SAN FRANCISCO
OCEAN BEACH STORM DAMAGE
REDUCTION STUDY

Final Report

Submitted to:
U.S. Army Corps of Engineers
San Francisco District
April 28, 1994

by

Sujin Park & Sydney Reddy

Prepared under the Guidance of:

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Anthropologist
U.S. Army Corps of Engineers

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I. STATEMENT OF OBJECTIVES

As part of evaluating the potential environmental effects of the proposed shoreline protection project at San Francisco Ocean Beach, the U.S. Army Corps of Engineers, San Francisco District, felt it necessary to identify how the project would likely affect people who (a) use, (b) reside near, or (c) otherwise are concerned with the study area. The purpose of this study is to assist the Corps project planners in designing the most suitable project that avoids or reduces any undesirable effects and yields the greatest public benefit.

In November 1993, the U. S. Army Corps of Engineers contracted with Sujin Park, San Francisco State University graduate student in Urban Anthropology, to investigate and identify the social environmental concerns of the proposed project. She was assisted in the fieldwork and writing of this report by Sydney Reddy, a fellow graduate student. Following the guidelines provided in the Scope of Services, sections 3.0 to 3.5, data was collected from November 10, 1993 to January 22, 1994.

The analysis of our findings is organized into sections that correspond to four distinguishable and recurring themes revealed in the interviews: 1) general responses to the Army Corps' proposed options; 2) skepticism on the Army Corps' expertise; 3) the Army Corps' handling of project information; and, 4)provisional requests during construction. The researchers tried to remain impartial to all issues raised by those interviewed. The researchers' aim has been to provide the means for a number of concerned citizens' and organizations' opinions to be heard by the Army Corps of Engineers.

II. METHODOLOGY

The primary approach used to collect data for this report involved the use of discussion oriented interviews. Twenty-eight people were directly interviewed, mostly in-person, and a few over the telephone. These interviews ranged from a brief fifteen

minutes to as long as eighty. The erosion problem, proposed corrective options, and other related issues were discussed.

The researchers solicited interviews with individuals from the December 1992 public meeting mailing list provided by the Corps and from circulation of flyers. Flyers were posted around the Lower Great Highway area in places such as the Java Beach Cafe, public rest-rooms, local laundromats, shops and on sign posts. In addition, the researchers contacted a neighborhood newspaper, the Sunset Beacon. An article about the social study and the Ocean Beach project was published in the January issue requesting for public's input. A few interviews were obtained by simply walking along Ocean Beach and asking people if they would be interested in talking on the subject. The researchers also attended several meetings, including that of the Lakeshore Acres Improvement Association, the Tides End Community Association and the Citizens Advisory Committee on Clean Water.

The interviews were conducted in an unstructured and informal manner as a way of providing the optimum opportunity for the interviewee to voice his/her views, opinions, comments, etc. After a briefing on the project (refer to appendix 3, pg. 25), the details of which depended on how much information the interviewee already had, some basic questions (such as full name, address, group affiliation, length of residency, beach use, etc.) were asked. The discussions, however, usually centered around the issues initiated by the interviewees.

Note on the Usage of Collected Data

Although a count of where people stand on the issue of erosion protection is provided in the appendix, the researchers discourage making any major significance of this information for several reasons. First, the sample size of this study cannot be assumed as a true representation of the majority view. Attempts to conduct any kind of statistical analysis of the numbers in this study should be minimized. Second, many people do not hold a firm

position on any particular option. They elected, instead, to wait for more information. Many did allude to their preferences but, even then, these were rather tentative. Lastly, the motivation of particular view point and of special interest groups must be considered. For example, the oppositional groups may be smaller in numbers than those more open to the possibilities; but the former ones are far more motivated to act and organize. Consequently, the Army Corps' decisions should not be based on the opinions of the "majority", since it is not truly available from this study and, since an active minority is far more effetive than a passive majority.

III. ASSESSMENT OF COLLECTED DATA

1. On Army Corps' Proposed Action

A) In Favor of Action:

Although the majority of the people interviewed expressed skepticism of the necessity of taking action (see section 2), a handful of people assented to the Army Corps' assessment of the erosion problem along Ocean Beach and, to the recommendation of countering the anticipated damage. Such favorable response came from people who are familiar with the related issues on an authoritative level (i.e. government personnel) and those who live outside of the Great Highway area. Amy Meyer, for instance, is a retired city official and Co-Chair of People for Golden Gate National Recreation who has been involved, extensively, with the launching of the sewer box project. She gave an argument in favor of the Army Corps' proposal by asserting her authoritative opinion of taking action:

> "We are dealing with an unnatural situation [at Ocean Beach]... If people want a natural situation [taking no action], the consequences are much more dire. This is an artificial landscape situation."

Similarly, other government employees, like Terry McDonald (Gardener Supervisor for Golden Gate Park) and Ellen Johnck (a

former Coastal Commissioner) also communicated their professional knowledge on behalf of the Army Corps' proposal of taking action. Distant residents who will not be affected directly by construction activity generally conceded to the Army Corps' expertise on the issue. For example, Bruce Selby, president of the Lakeshore Acres Improvement Association (speaking for himself in this instance), expressed that since he was not a resident within the construction area, the proposal for action is not a major concern for him.

Despite their consensus on taking action, however, their choice on options varied.

B) Dune Enhancement

People who favor dune enhancement prefer this option mainly because of its natural esthetics qualities and low construction cost. The idea of having dunes to feed and maintain the beach, as well as its natural appearance make this option most suitable environmentally and pragmatically. A seawall, in their view, does not accommodate these desired effects and tends to attract graffiti which they see as a displeasing sight of urban decay. Furthermore, they pointed out that seawalls are not very well maintained (scattered and uncollected garbage, overblown sand piles, graffiti, and the smell of urine) which adds to their disapproval of this option.

Some concerns regarding the dunes have been raised which require the Corps response. The researchers suggest that the following questions be addressed at the recommended public forum (refer to page 15):

1) Terry McDonald, among few others, would like to know "who would be responsible for the overall maintenance of the dunes after the Army Corps complete the replenishment."

2) Concerns about the trampling of dune grass and how it will be kept under control were two of the most frequently raised questions. One beach user we spoke with, Michael Young,

suggested setting up of as many trails as possible on newly replenished dunes to reduce this problem.

3) Kingsly Roberts of the DPW and a few others wondered whether sand that is piled up against the seawall could be used for dune replenishment.

C) Seawall:

People who advocate the seawall option are under the impression that it would be a more permanent solution to the erosion problem. Their objection to the dune option stems primarily from the fact that it necessitates periodic replenishment which involves construction related activities such as trucking of sand and restricting ("fencing off") of certain beach access. This kind of maintenance requirement is deemed to be "endless waste of money" and "disruptive" to their serene and (semi-) natural social environment. Specifically, they showed strong disapproval of the idea of having limited beach access for an estimated 400 working days every ten years or so.

A few individuals believe that the dune construction, as well as the possibility of inadequate maintenance of the established dunes, would increase the sand blowing/piling problems on their streets. This presumed problem, needless to say, further contributes to their preference of the seawall option and opposition to the dune option. "Does GGNRA and the Army Corps expect us [home owners] to clean up the mess?" This statement, made by Marty Larkin (president of the Tides End Community Association and a Great Highway resident) summarizes these individuals' annoyance at the sand blowing/piling problem and why they prefer a seawall over dunes.

Many share the view of James Walsh (an occasional beach user who mainly likes to walk along the seawall) who regards a seawall as a solid measure that would take care of the problem once and for all, unlike dune replenishment. Those who side with this view also point out that any strong storm could "wash away the dunes

overnight." They enjoy the Great Highway seawall very much as a multipurpose recreational walkway and don't find the loss of a dune system to be problematic. Moreover, they are not convinced that the erection of a seawall will result in loss of the recreational beach area. If the Army Corps decides on the dune option, they asked to be provided with a compelling argument, with necessary factual information, as to why the dune option was chosen over a seawall.

D) Alternative Solutions:

Some interviewees offered alternative options that the Army Corps did not present or had already ruled out. Usage of boulders to anchor the dunes, for example, have been suggested by several individuals including David Ferguson (a longtime resident who uses the beach area often), Peter Baye (an Army Corps employee) and David Rodriguez (surfer/resident). For Mr. Ferguson, placing boulders on the beach and building dunes over them appears to be the most feasible way to secure and stabilize the dunes which he believes would require less maintenance and shorter construction time. He is dissatisfied with the way the "authorities" (city officials) simply ruled out this option on the basis of what seems to him an arbitrary regulation (GGNRA's restriction on hard structure-related method) and contrary to the goal of seeking out the best solution.

A similar position was taken by Mr. Rodriguez and Mr. Baye who recommended the combination of different options to design "the most efficient and least environmentally damaging protection project". Mr. Rodriguez suggested applying both the seawall and the dune methods. A permanent hard structure like the seawall, he insisted, would provide maximum protection as a back up in case the dunes fail during a harsh storm; the dunes, of course, would provide a buffer-zone kind of protection as well as feeding of the beach. As for Mr. Baye's suggestions, unfortunately, we were unable to meet with him for an elaboration on his alternative

ideas. Nonetheless, a brief phone conversation with Mr. Baye suggested that he would support such a combination method because his concerns are on the effectiveness of the project and its consistency with the environment.

Finally, a third suggestion came from Mike Hummel who informed us of an article in the January issue of Popular Science (appendix 7). The article reports on the use of experimental breakwaters being used to combat beach erosion on New Jersey's shores. Hummel prefers this idea not only for its relative low cost but, also because he was very troubled by the proposed 400 working days of construction time. This option, he suggested, should be considered because it would be a one-time project and would still save the recreational beach.

E) Other Related Concerns:

The main concern for Dan Murphy from the Golden Gate Autobahn Society was on how the project would likely affect the seasonal bird population of the area. When he was informed that the Army Corps plans to take steps to ensure the safety of the birds in the area, namely by avoid working during their nesting periods, he seemed satisfied. He will be monitoring the area as the project develops and requested to be kept updated, especially on the access to the site during construction.

Likewise, Jacob Sigg, from the California Native Plant Society, wanted to make sure that the Army Corps be aware of the Presidential Executive Order (11987 Sec. 2) which "restricts the introduction of exotic species into the natural ecosystems" (an effort to restore native plants) and, that the Army Corps comply with this law by using plants listed on his letter sent on December of 1992. When informed that the Army Corps plans to comply with the regulation, his concerns seemed appeased but noted that monitoring of the Army Corps' activity will continue.

Jeff Greenbaum, a local hang-glider shop owner, was concerned about how the project would affect the recreational use of the

beach. As a recreational businessman interested in establishing a hang-gliding training area on the beach dunes, Mr. Greenbaum inquired whether Army Corps' would support such an idea or not. He added that Ocean Beach area has a very large following of hang-glider enthusiasts and that they "would love to have their tax dollars working for them." We responded to Mr. Greenbaum's entrepreneurial inquiry by suggesting he summit a formal proposal to the park and recreation division.

Mark Massara, a representative of the Surfriders' Foundation and a resident at the Great Highway, monitors major shoreline construction activities across the States. He urges the Army Corps to recognize the importance of San Francisco's Ocean Beach as a nationally renown surf spot, listed on the world's top ten scale. Since the publication of "Playing Doc's Games" by William Finnegan in the "New Yorker" magazine, August 92 (refer to appendix 7) which documents the cultural and social history of Ocean Beach and its surf riders, Massara believes that the beach will soon become a national treasure spot if it is not already. The waves at San Francisco, according to the article (Finnegan 92: 40) are some of the best in California. Massara and members of the Surfriders' Foundation request that extra sensitivities be taken with any shoreline project that will affect the wave patterns. Ideally, they would like the Army Corps to conduct a surf study as was done at Huntington Beach, California.

Furthermore, Massara asserts that the data presented by the Army Corps (in the Reconnaissance Report), which he has carefully reviewed, is "not persuasive enough to justify the measures they are proposing." He believes the rate of erosion stated by the Army Corps (five feet per year) is inaccurate and will challenge ACE's data technically and legally if necessary. He suggests that ACE provide more information on erosion with substantial evidence.

Overall, the people who firmly favor some sort of action are somewhat outnumbered when compared to the group who questioned the necessity of the project in the first place.

2. <u>Is Action Necessary</u>

The citizens that question the necessity of action make up the majority group. They are not convinced that problematic erosion is occurring at Ocean Beach and remain skeptical of the need to take action. This group, however, is split into two factions: those open to further information before taking a firm position on the issue and, those who disagree, based on their own observations and personal knowledge, with the necessity of taking action.

A) Not Convinced But Open:

The predominant sentiment expressed by the majority of the interviewees was that not enough information has been provided to convince them of a serious erosion problem at Ocean Beach. Aside from one public hearing in December of 1992, some alleged, no other attempts have been made to disseminate information on the problem nor on the project until the commencement of this social study. Allen and Jennifer Davis's (resident/members of Surfrider Foundation) request for a greater availability on all relevant information including those considered technical is supported by the majority interviewed.

Though skeptical of the seriousness of the erosion problem, some are not completely against the idea of taking a preventive action. For their supportive cooperation, they ask to be fully informed of the problem and the project's development. Presentation of hard data such as photographs or detailed historical information, and an opportunity to hold question-answer dialogues with people directly involved in the project, are what they would like to see before taking a stand on the issue. Although they would rather make the decision after learning more details, they expressed tentative preferences for either the seawall or dune option (refer to appendix 1).

B) Strongly Not Convinced:

Some people, on the other hand, are strongly unconvinced of critical erosion problem along Ocean Beach nor of imminent storm damage to the structures; hence, they prefer no action alternative. Characteristically, they are either active voluntary organization members or long-time (20 to 30 years) residents. The most vocal dissentient view came from the members of the Tide's End Community Association (T.E.C.A.) and the Sunset Coalition (S.C.) who would like to remind the Army Corps that residents will have to live with the decisions made by the Corps every day. With little hesitation, they openly criticized on the handling of the previous Ocean Beach projects (the Promenade seawall and the sewer box which apparently were problematic) and, on the inefficiency and wastefulness of bureaucratic operations.

Central to the argument posed by contentious or skeptical individuals is the notion that "summer build-up" and "winter wash-out" is a natural process needing no human intervention. These strongly unconvinced individuals assert that they have not noticed any serious erosion problem that warrants protective construction. Flora and Jerry Zagorites, a native San Franciscan and chair of Citizen's Advisory Committee on Clean Water respectively, state their position by basing it on their historical observation:

> "If you stand at the Cliff House and look at the south end of the beach, in the winter months, it's a short beach and in the summer months, it's a wide beach. It's been that way since she [Mrs. Zagorites] was born here" (Mr. Zagorites).

> "I have been living here [near the beach] for decades. ... What we have seen in all those years is that the beach breaks down during the winter and builds up during the summer" (Mrs. Zagorites).

Unless the Army Corps present contradictory data invalidating the decades of resident's close-range observation, Mr. and Mrs. Zagorities as well as numerous other unconvinced individuals who hold similar contention of no action (including Mr. Massara, Tainter, Walsh, and Pierce) will continue to disapprove of the shoreline protection project.

Mistrust of government agencies, cultivated by negative experiences over the years (specifically with failed A.C.E. projects), further adds to their un-yielding skepticism. For example, Tim Pearce (surfer and frequent beach user since the 1960s), states:

> "...these government agencies always do what *they* [his emphasis] think is best and don't give much consideration to the people who live around and use the beach."

Others have remarked that a project proposal such as this is just another form of job security plan.

On the choice of option if preventive action is deemed necessary, some favored a seawall as a permanent solution without the hassle of periodic construction activity, which they have grown weary of, while others preferred dunes for its natural esthetics and environmental compatibility. Nevertheless, they remain strongly unconvinced of the existence of an erosion problem; and, to win their consent, their dissentient opinions need to be proven otherwise.

The lack of substantial or convincing data on the actual erosion tend to engender much skepticism among those concerned. Everyone, except for those officially tied to the project, in the end, asked for more information which allegedly has not been adequately provided by the Army Corps. Jerry Zagorites put it simply by saying, "The Corps has not presented a good case." This perceived deficiency of information also has the effect of instilling suspicion and cynicism among some residents. As mentioned earlier, a few wondered whether the Corps' main intention in this project was "to protect their jobs" or "to give themselves work". The best way of resolving this problem of apprehension, we believe, is to develop better public relations. The outline of suggestive recommendations for better public relations can be found in page 14 of this report.

3. On Construction Activities

General Response and Five Provisional Requests:

> "Here we go again! We are fed up with these constructions," David Ferguson, native San Franciscan and resident activist.

Displeasure and disapproval generally describe the way residents, beach users, and members of voluntary organizations concerned with the study area reacted to the project proposal requiring construction activity. Many people, especially the long-time residents, are weary of constant construction work taking place at Ocean Beach. Fieldnote on Mr. Ferguson's comments exemplifies such weariness:

> Mr. Ferguson enjoys seeing sparkling sand, magnificent waves, and glowing sunsets right out from his window. He is very distressed, however, by endless construction activities around the beach which creates disruptions. He feels that as soon as one project is finished, the government proposes another one and the beach residents are never free from the construction noise, the sight, traffic congestion, and pollution.

Nonetheless, if the Army Corps proceeds with the shoreline protection project, they request that the following provisions be granted to appease the inconvenience they would have to endure:

Provisional Request 1: Provide a "citizens' assistant" or a kind of ombudsman who oversees and monitors the construction process. He or she will act as an impartial mediator between the construction people and the residents and/or beach users in case any complaints or disputes arise.

Although this idea is ardently supported by the majority, conflicting opinions have been voiced as to *who* would be most appropriate for this position. Mr. McDonald, Golden Gate Park Gardener Supervisor and a Great Highway resident, suggested encouraging residents to volunteer and participate in overseeing the construction process. On the contrary, Ms. Meyer, Co-Chair of People for Golden Gate National Recreation, warned that this position must be filled by a person outside of the community, who

will be responsible to the project manager, in order to prevent political polarization.

Still yet, a few skeptics like Ms. Grimm and Mr. Carmen from S.C. and Mr. and Mrs. Larkin from the T.E.C.A. think that the idea of hiring a go-between person is an "unnecessary, bureaucratic waste of tax-payers' dollars." They argue that anyone within reach of a telephone can easily contact the project manager to report complaints. Should any issue become a serious dispute, an ad-hoc committee can be formed to discuss and resolve the matter.

Provisional Request 2: Request for a pre-construction meeting detailing the construction method (i.e. how it will be carried out and what it entails) is unanimously supported by everyone interviewed. Announcements of this meeting should be thoroughly publicized near and at the project site. This should include posting flyers or notices and contacting the local newspaper agencies.

Provisional Request 3: If trucks are required for the project, a general description of their activities, routes, number and size should be explained.

Provisional Request 4: A pre-construction condition survey should be taken of homes along the lower Great Highway in case someone make a damage claim after construction begins. In addition, information on compensation procedures is requested to be available through the project manager or through the ombudsman.

Provisional Request 5: Construction work after dark should be restricted. But if such a need arises, for instance to accommodate wildlife preservation, then the public should be notified and a decision should be made with the residents' input.

4. <u>On Army Corps' Public Relations Efforts</u>

Views Expressed and Four Points to be Considered by ACE:

> "With projects such as this, I think communication with the public or the people most directly affected is absolutely critical and should be a foremost consideration by the Corps" Bruce Selby, President of the Lakeshore Acre Improvement Club.

Many concerned citizens and voluntary organization members expressed dissatisfaction with the Army Corps public relations and communication efforts and demanded an improvement in this area. Although sending out one or two informant/researcher(s) is generally appreciated, they express this effort alone does not adequately meet the public's demand for wider dissemination of project related information.

Many residents and voluntary organization members have been following Ocean Beach related projects for years and are attentive to the details of new project proposals. Members of the Sunset Coalition and the Tides End Community Association, for example, have actively been involved in the planning of the Great Highway Seawall. Special interest groups like the Surfriders Foundation, a non-profit organization dedicated to protection of coastal environments, have their own specialist who monitors major shoreline projects. They ask that details of the Army Corps' plan of action, updated information, schedules and other necessary information be sent out to the concerned groups or individuals for proper feedback.

Some long-time residents who have witnessed and lived through numerous previous projects ask that their historically observed insights be given equal attention by the project planners and accordingly responded. For instance, one of the long-time residents' (and others') main contention to the current proposal is on the necessity of taking action. Like many other group representatives and concerned citizens, long-time residents are not convinced of an erosion problem. They request that the engineers propose a strong and fairly easy-to-understand argument

to back up their conclusion. For instance, they would like to see historical photographs or a computer generated model showing the supposed affect of erosion over the next fifty years.

In general, the majority of concerned citizens and organization associates pointed out the essential fact that they are the ones who fund and are affected by these projects. Therefore, they assert, the authoritative personnel involved in such projects should prioritize on informing, consulting with and answering to the concerned public. The importance of this latter point is emphasized by Mr. Mamak, Director of Public Information and Public Participation, S.F. Department of Public Works, who states, "public support and input is necessary. It is the pragmatic approach [to good project planning]."

The following suggestions should be considered by the Army Corps as ways to better inform the public.

Recommendation 1: Hold a public forum at which an informative dialogue and exchange of ideas between the Army Corps' project personnel and the representatives from concerned citizens' associations can take place. This event would provide the opportunity for the public to ask questions and get immediate answers from the experts and the authorities themselves. Representatives from every sector involved in the project should be contacted such as DPW, Coastal Commission, GGNRA, and those on the mailing list. This should be organized approximately a month after the release of the Environmental Impact Statement.

Recommendation 2: Announcement of the EIS release should be widely publicized in neighborhood and city newspapers like the Sunset Beacon, Independent, Chronicle or Bay Guardian.

Recommendation 3: Many favor the idea of circulating a newsletter or some form of update reports containing information on new developments of the Ocean Beach projects, announcements of meetings, progression of construction, etc.. First issue of this newsletter should be sent to everyone on

the provided mailing list (appendix 2). It should enclose a sign-up card for those who wish to be updated further. The sign-up card should also ask whether people would be interested in forming a committee that address issues surrounding future Ocean Beach projects. If such a newsletter or update report is not fiscally possible, then, local newspaper agencies should be provided with consistent information.

Recommendation 4: Contribute all necessary literature materials and documents to local libraries (Ortega and Sunset branches) for convenient resource access.

V. CONCLUSION

"The real issue is what is the best solution?" David Johnson, resident activist.

Skepticism and apprehension best describes the general public's sentiment towards the Army Corps of Engineers and their track record. Numerous interviewees were all too willing to provide the researchers with examples of failed or mis-planned projects that the Army Corps had previously worked on throughout the continent. At one instance during an interview (with a representative of the Surfriders' Foundation), the researchers were handed a book called "Dams and Other Disasters" which documents hundreds of disastrous projects carried out by the U.S. Army Corps of Engineers.

Despite this prevailing skepticism, everyone interviewed is willing to concede to the Army Corps' expertise and support their recommendation if two commitments can be made by the Corps: one, that the Army Corps' public relations be improved following the guidelines provided in this report; and two, that the decision be based primarily on what is the most effective long term solution and the least environmentally damaging and not only on fiscal politics.

APPENDICES

BIOGRAPHICAL INFO AND COUNT

1) Ach, Jay
-Concerned resident and surf rider/beach user.
-No action preferred but would support the dune option.

2) Arack, Patricia
-Resident Activist
-Dune option preferred.

3) Baye, Peter
-Concerned resident and ACE environmentalist.
-Alternative option preferred.

4) Carmen, Charles
-Member of the Sunset Coalition, long-time follower of Ocean Beach projects.
-No action but seawall if necessary.

5) Chamoro, David
-Occasional beach user.
-Best solution*[1] preferred.

6) Davis, Allen and Jennifer
-Resident and surf-rider/beach users.
-No action but dune option if necessary.

7) Grimm, Elaine
-Co-Chair of Sunset Coalition, a resident activist, long-time follower of Ocean Beach projects.
-No action but seawall if necessary.

8) Greenbaum, Jeff
-Business owner on Sloat.
-Dune option preferred.

9) Hummel, Mike
-Resident, article contributor.
-Alternative option preferred.

10) John, Ellen
-Previously worked for the Coastal Commission.
-Dune option preferred.

---

* This category, as the others, is arbitrary. In the researchers' opinion, people in this group were actually willing to leave the decision up to the Army Corps and its negotiations with other citizens in devising the "best solution".

11) Johnson, David and Sours, Phil
-Resident activist.
-Dune option preferred.

12) Khun, Thomas
-Executive member of the Friends of Sutro.
-Dune option preferred.

13) Larkin, Marty and Frances
-President and member of the Tides End Community, also native San Franciscan, and long-time followers of Ocean Beach projects.
-No action but seawall if necessary.

14) Massara, Mark
Attorney, Surfriders Foundation, and a resident.
-No action preferred but will support dune option.

15) Mamak, Alex
-Director of Public Relations and Communication, D.P.W.
-Best solution preferred*.

16) Martin, Gabriel
-Occasional beach user.
-Best solution preferred*.

17) McDonald, Terry
-Gardener Supervisor for Golden Gate Park
-Ocean Beach area resident and frequent user
-Dune option preferred

18) Meyer, Amy
-Co-Chair of People for Golden Gate National Recreation
-Dune option absolutely.

19) Murphy, Dan
-Golden Gate Autobahn Society
-Best solution preferred*.

20) Pearce, Sarah and Tim
-Concerned resident and surf-rider.
-No action preferred but would support dune option.

21) Randolf, Dian
-Concerned resident.
-Seawall preferred.

22) Rodriguez, David
-Concerned resident and surf-rider.
-Alternative option preferred.

23) Selby, Bruce
-President of Lakeshore Acres Improvement Association.
-Best solution preferred*.

24) Sigg, Jacob
-California Native Plant Society
-Best solution preferred*.

25) Tainter, George
-Member of Citizens Advisory Committee and concerned long-time resident.
-No action preferred but would support seawall option.

26) Walsh, James
-Concerned resident
-No action preferred but would support seawall option.

27) Zagorites, Jerry and Flora
-Chair of CAC and native San Franciscan resident.
-No action preferred but would support seawall option.

28) Young, Michael
-Occasional Beach User.
-Dune option preferred.

COUNT

-Dune Preference: 8

-Seawall Preference: 1

-Alternative Solution: 3

-No Action Preference: 14

-Best Solution: 6

MAILING LIST

I. Individual Mailing Address:

Ach, Jay
10 Rockridge Dr.
S.F., CA 94116
(415) 664-4551

Arrack, Patricia
1900 Great Highway
S.F., CA 94116

Baye Peter
1434 Moraga
S.F., CA 94121
(415) 631-6820

Carmen, Charles
1648 Great Highway
S.F., CA 94122
(415) 665-8399

Chamorro, David
1705 Alabama St.
S.F., CA 94110

Hummel, Mike
2654 46th Ave.
S.F., CA 94116

Johnck, Ellen
44 Dotomac St.
S.F., CA 94117
(145) 397-2293

Johnson, David & Sours, Phil
1762 Great Highway
S.F., CA 94116

Kligelhaffer, Bill
1638-18th Ave.
S.F., CA 94122

Kuhn, Thomas
546 48th Ave.
S.F., CA 94121

Martin, Gabriel
1129 21st. Ave., S.F. CA 94111

Pearce, Sara & Tim
2131 Great Highway
S.F., CA 94116
(415) 664-2179

Randolf, Dian
1910 Great Highway
S.F., CA 94116
(415) 661-9375

Renneker M.D., Mark
2396 48th Ave.
S.F., CA 94116
(415) 664-1927

Reich, Peter
20 California St.
S.F., CA 94111
(415) 399-0140

Rodriguez, David &
Kunzman, Dagmar
1300 La Playa #6
S.F, CA 94122
(415) 665-4678

Walsh, James
2662 40th Ave.
S.F., CA 94116
(415) 564-0751

Young, Michael
830 Arguello Blvd.
S.F., CA 94118
(415) 666-3703

Tainter, George
154 Lake Merced Hill
S.F., CA, 94132

Zagorites, Jerry & Flora
4750 Ocean Ave.
S.F., CA 94132

II. Organization List:

(Note: A copy of this report should be sent to agencies marked with double star* sign.)

California Coastal Commission
Steven Scholl, Assistant Director
45 Fremont St. Ste. 2000
S.F., CA 94105-2219
(415) 904-5260

California Native Plant Society
Jacob Sigg
338 Ortega St.
S.F., CA 94132

**Citizens Advisory Committee on Clean Water
P.O. Box 360
1550 Evans Ave.
S.F., CA 94101

**Coalition for Great Highway and Ocean Beach
1878 Great Highway
S.F., CA 94122
(415) 661-1041

**Department of Public Works, City and County of San Francisco

Bureau of Engineering:
Karen Kublick
1680 Mission St.
S.F., CA 94103
(415) 554-8214

Public Affairs:
Alex Mamak
1550 Evans Ave.
S.F., CA 94124
(415) 431-9430

Golden Gate Autobahn Society
Dan Murphy
2945 Ullo St.
S.F., CA 94116
(415) 564-0074

**Golden Gate National Recreational Area
Jim Milestone
Park Planner: Nancy Horner
Superintendent: Brian O'Neill
South District
Fort Mason, Building 201
S.F., CA 94123

**Golden Gate Park Gardener Supervisor
Terry McDonald
McLaren Lodge
S.F., CA 94117
(415) 753-7040

Hang Time Hang-Gliders
Jeff Greenbaum, Owner
3620 Wawona St.
S.F., CA 94116

Java Beach Cafe
1396 La Playa
S.F., CA 94122
(415) 665-5282

Lakeshore Acres Home Improvement Association
336 Country Club Dr.
S.F., CA 94132
(415) 661-3807

People for Golden Gate National Recreation
Amy Meyer
3627 Clement St.
S.F., CA 94121

**Public Libraries:
Ortega Branch
3223 Ortega St.
S.F., CA 94122
(415) 753-7020

Sunset Branch
1305-18th Ave.
S.F., CA 94122
(415) 753-7130

San Francisco Bay Conservation and Development Commission
Steven Goldbeck, Coastal Program Manager
30 Van Ness Ave. Ste. 2011
S.F., CA 94102-6080
(415) 557-3686

**San Francisco State University
Department of Anthropology
Kefflin Vitina, Department Secretary
1600 Holloway Ave.
S.F., CA 94132
(415) 338-2046

**Sunset Beacon (Neighborhood Newspaper)
Chris Rivers, Publisher
P.O. Box 22427
S.F., CA 94122

**Sunset Coalition
Elaine Grimm
1924 Great Highway
S.F., CA 94116
(415) 566-3345

**Surfrider Foundation
Legal Office:
Mark Massara
1642 Great Highway
S.F., CA 94122
(415) 665-7008

San Francisco Bay Chapter:
Allen & Jennifer Davis
2110-17th Ave.
S.F., CA 94116
(415) 759-7189

**Tides End Community Association
Frances & Marty Larkin
4733 Lincoln Way
S.F., CA 94122
(415) 566-2002

U.S. Fish and Wild Life Services
Richard De Haven
2800 Cottage Wy. Rm. E1803
Sacramento, CA 95825
(916) 978-4613

III. Researchers' Address:

Contract Researcher:
Sujin Park
830 Arguello Blvd.
S.F., CA 94118
(415) 387-0136

Research Assistant:
Sydney Reddy
405 Serrano Dr. #9L
S.F., CA 94132
(415) 587-7422

FACT SHEET

(Used by Researchers)

I. The Problem - known since 1965

1) Storm damage and high erosion area:
   *The El Nino storm (1982-3) -- O'Shaughnessy Seawall, Noriega and Santiago St.

2) Beach erosion:

3) The Great Highway and the Sewer conveyance box:
   *Vulnerable to storm damage erosion if the currently existing protection fails: a) Moraga to Noriega, b) Taraval to Ulloa, c) Sloat to south of the Funston bluffs.

4) Sand blowing:

II. A.C.E., The Reconnaissance Study & the Alternative Options:

Discuss the **pros and **cons** of theses proposed alternatives--the cost, the impact, aesthetics, etc.

1) Beach-nourishment--massive nourishment of the beach.
   *Highest cost alternative, $69 million.
   *Requires periodic replenishment.
   *Will not be funded by the federal government. The city cannot afford the expense.

2) Rock revetment--protecting the bank with a slope area and rocks on top of it. Takes most land encroaching on the GGNRA beach property.
   *$35 million.
   *It would have to be built on GGNRA property which would not be allowed by the GGNRA and the Coastal Commission.

3) Seawall--the O'Shaughnessy type.
   *$42 million.
   *Could be built on city property.

4) Dune-nourishment
   *$13 million.
   *Needs to be replenished periodically.

***The **expense** will be shared-40/60 by the city and the fed.
-The city fund will come from the escrow account that the Coastal Commission required during the seawall and west side transport construction for a nourishment program. The city share of the cost already exists. It is the money set aside and funded by the interest on the escrow account.

5) <u>No action</u>--if the existing protection fails and the sewer box ruptures, the damage may lead to possible violations of environment and clean water regulations.

III. Involvement of the Army Corps of Engineers:

1) Mission - to protect and enhance water resources;
to reduce damages from water resources (nation-wide) such as damage or potential damages at the Ocean Beach.

2) Contacted by local agency (City and County of S.F.) through Congressional representatives.

3) Reconnaissance Study - to determine the problem and to identify possible solutions, including at least one that appears to be feasible from environmental, economic and engineering perspectives.

4) Feasibility Study - deciding process of what method should be applied.

*Expected date of the report - Oct., 94 for a draft Sep., 95 for a final report.

IV. Feasibility Study:

1) <u>Objectives</u>:
*To provide further protection for the Great Highway and the sewer transport box from the destructive ocean storm waves.

*Currently, this is being done by the network of dunes and seawall already in place. But the dune system is eroding and is insufficient in certain areas to provide an appropriate level of protection.

*To study the effects of the increasing dune width on the level of protection afforded.

2) <u>The dune nourishment</u>: "soft engineering solution"

a) Elements of the system:
The dune is part of a system which includes the beach berm and underwater sandbars. If the beach berm and underwater bars are deficient in sediment, the dune will become more susceptible to erosion and erode at a faster rate and endanger the structures behind them.

b) <u>Process of the study:</u> see page 15
Computer simulation; Historic aerial photographs; Surveys; and Sand grain size for discerning dune stability.

Copy of Flyer (#1) Used.

"Think globally, act locally"

ATTENTION

Fellow San Franciscans,.

Those who care about our environment,
Those "brave souls" who ride the waves,
Those who simply like the Ocean Beach and its natural habitat
and
Want to prevent further pollution,

We urge you to have a say in the proposed shoreline protection project currently being assessed by the US Army Corps of Engineers in conjunction with the City and County of San Francisco.

According to the Reconnaissance Report conducted by the Army Corps, eroding Ocean Beach, an estimated rate of two to five feet per year, and high storm waves, like those in1982 El Nino storm, will have damaging effects to the Great highway and the sewer transport box beneath it violating number of environmental and clean water laws.

Through independent researchers, the Army Corps is soliciting general publics' response to their proposed actions.

Learn more about the project and have your voice be heard.
Please give us a call or write us with your opinions, comments, suggestions, or views.

Ocean Beach Social Environmental Study
830 Arguello Blvd.
S.F., CA 94118

Sujin Park (415) 387-0136
Sydney Reddy (415) 587-7422

You can also contact the Army Corps directly at
211 Main St.
S.F., Ca 94105
(415) 744-3363

Copy of FLYER (#2) USED.

12/8/93

ATTENTION

A BUILDING PROJECT ON THE **OCEAN BEACH** AREA IS BEING PLANNED BY THE U. S. ARMY CORPS OF ENGINEERS. THE PROJECT INVOLVES THE STRENGTHENING OF PARTICULAR **DUNE** STRUCTURES ON OCEAN BEACH TO FIGHT EROSION IN THESE AREAS.

* *

THE ARMY CORPS IS CURRENTLY CONDUCTING A SOCIAL IMPACT STATEMENT AS PART OF THEIR ENVIRONMENTAL IMPACT STATEMENT. THE CORPS IS NOW **SOLICITING COMMENTS** FROM PEOPLE WHO HAVE AN INTEREST IN THE OCEAN BEACH PROJECT. AREA RESIDENTS, SURFERS, JOGGERS AND ANY OTHER BEACH USERS ARE PLEASE URGED TO CONTACT THE CORPS' RESEARCHERS BELOW SO THAT YOUR OPINION MAY BE HEARD.

THANK YOU.

SUJIN PARK (415) 387-0136
SYDNEY REDDY (415) 587-7422

ATTENTION

Copy of Interview Solicitation Letter.

12-28-93

Ocean Beach Social Environment Study

Sujin Park
830 Arguello Blvd.
San Francisco, CA 94118
(415) 387-0136

Sydney Reddy
405 Serrano Dr. #9L
San Francisco, CA 94132
(415) 587-7422

To: ________________

From: Sujin Park and Sydney Reddy, contract researchers for the Social Environment Study, US Army Corps of Engineers.

Re: The Ocean Beach Storm Damage Reduction Feasibility Study.

Dear Mr.________________:

The US Army Corps of Engineers has asked us to assess the environment related social concerns the residents and the beach users have regarding the proposed storm damage reduction project at Ocean Beach.

The mail list and the issues noted from the last year's public meeting have been forwarded to us, independent contract researchers, for further evaluation of public's concerns. Our job is to write a *people's report,* to enhance the public's voice in governmental actions that have direct and indirect effects in our environment and our life-ways. Identified and amplified people's concerns, objections or supports will enable the Army Corps to take the most appropriate action in preventing the pollution-prone damage of the Great Highway and the sewer transport system beneath it.

As you may already know, numerous concerns raised at the meeting are being regarded by the Army Corps, such as 1) the sand quality, 2) restoration of the native plants, 3) setting up trails on the dunes to maintain the longevity of the plants, 4) wildlife conservation during construction period, 5) aesthetics and recreational preservation.

To adequately address the concerns specific to the residents/ beach-users and to collect relevant suggestions, comments, or points for consideration, we would like to set up an appointment with you and/or with the members of your organization to further discuss the project and any additional concerns that may form.

Our telephone numbers are noted above. Feel free to reach us at any time. Thank you. We look forward to hearing from you.

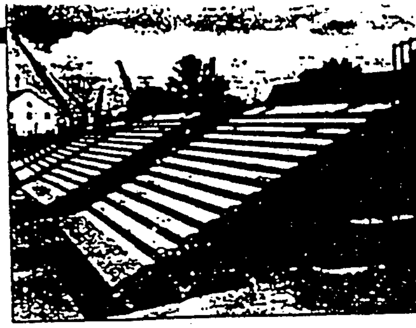
Sincerely,

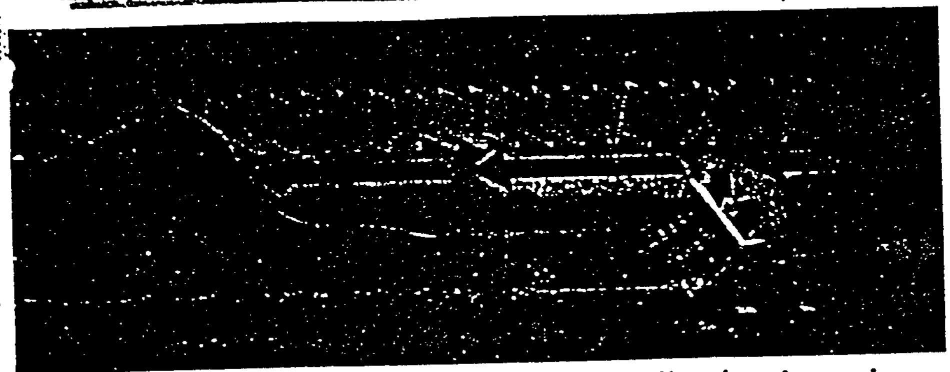
Sujin Park and Sydney Reddy

4

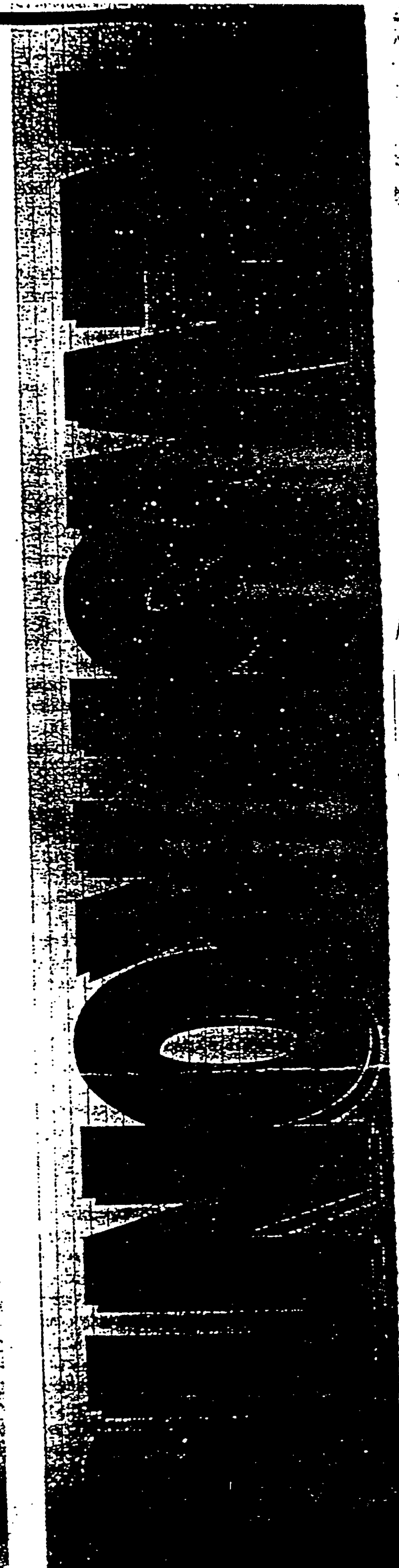
SCIENCE & TECHNOLOGY

EDITED BY DAWN STOVER





Beachsaver modules (top) are made from concrete and a microsilica additive that resists corrosion. Placed offshore, they channel water upward to create a "curtain" that blocks sand loss (above).



ENGINEERING

Band-Aid for Beaches

Beach lovers know the cold, hard facts: With every storm, raging ocean waves rip sand from the shore and carry it out to sea. According to some estimates, replacing the sand lost from U.S. beaches costs $1 billion a year. A new artificial-reef system could help stop the erosion.

Installed some 14 feet below the average low-tide level and parallel to shore, the Beachsaver system consists of interlocking, wedge-shaped concrete modules. Designed by Breakwaters International of Flemington, N.J., the 21-ton modules are 10 feet long, 15 feet wide, and six feet high. They combat sand loss three ways, says company president Richard E. Creter: Their ridged faces reduce sand-moving wave energy by as much as 30 percent; the patented modules create a "perch" for outbound sand so the next waves can carry it back to shore; and the sloped sides of the modules direct seabound water upward, creating a water "curtain" that prevents sand from escaping.

Three such reef projects in New Jersey are in the works. Funding for the $2.1 million program is being shared by the federal, state, and local governments.

Tests at the Stevens Institute of Technology in Hoboken, N.J., indicate that the artificial reefs won't damage sites farther down the shore in the direction of prevailing currents. Damage down-shore is a common problem with conventional breakwaters, offshore walls that protrude above the water.—*Mariette DiChristina*

MATERIALS

Artificial Ivory

Doing a good turn for elephants and pianists, engineers at Rensselaer Polytechnic Institute (RPI) in Troy, N.Y., have created artificial ivory that mimics the real thing, even at a microscopic scale. A 1990 treaty banned ivory imports, and piano makers have had to look for substitutes. Steinway and Sons, the famous New York maker of concert grands, asked RPI to develop something that would not only look like ivory, but also feel like it.

"Metal feels too cold to pianists' fingers," explains Salvadore Calabrese, who worked with fellow RPI scientist Henry Scarton to create a synthetic material called RPIvory. "And plastics are too smooth: As people play, their fingers leave sweat and oils on the keys, and soon their fingers slip and skid across the surface."

Examining real ivory under a microscope, the scientists found it has an irregular surface broken up by ridges, grooves, and pores. To precisely duplicate these features, they made a [illegible] mold—accurate to about a billionth of an inch—from an ivory key. They then poured plastic into this mold to make a new key. To create the pores, they mixed in a water-soluble powder, then dissolved it out with water, leaving tiny holes only 0.1 micron in diameter.

Concert pianists are now testing RPIvory keys, and Steinway says the early reports are positive. But piano keyboards may not be the only market for RPIvory, says Calabrese. Computer keys, steering wheels, and other [illegible] be made [illegible] —[illegible]

APPENDIX C5

Pre-Draft Environmental Impact Statement/ Environmental Impact Report for Ocean Beach Storm Damage Reduction Study

NOTE: This is only the introduction chapter and environmental laws and regulations chapters that were started on Pre-Draft EIS/EIR for Ocean Beach. It was originally in Humboldt EIS/EIR and was in process of being modified to fit Ocean Beach project when project was declared dead again.

DRAFT
ENVIRONMENTAL IMPACT STATEMENT/ ENVIRONMENTAL IMPACT REPORT

OCEAN BEACH STORM DAMAGE REDUCTION STUDY

SAN FRANCISCO CITY & COUNTY, CALIFORNIA

??? 1995

Prepared by:

US ARMY CORPS OF ENGINEERS
San Francisco District
Federal Lead Agency

CITY & COUNTY OF SAN FRANCISCO
State Lead Agency

1.0 NEED FOR PROJECT AND OBJECTIVES OF ACTION

1.1 PROJECT AUTHORITY

Authority for this study comes from the Congress of the United States which has directed the Corps of Engineers to make a study of beach erosion along the shores in San Francisco County, California, by the following resolution adopted on 3 August 1989 by the Committee on Public Works and Transportation, U. S. House of Representatives:

> "Resolved by the committee on Public Works and Transportation of the United States House of Representatives, that the Secretary of the Army, in accordance with Section 110 of the Rivers and harbors Act of 1962, is requested to make, under the direction of the Chief of Engineers, studies of the shores in San Francisco County, California, from the south county line to the Golden Gate Bridge and such adjacent shores as may be necessary, in the interest of providing protection to public facilities, storm damage prevention, and other related purposes."

1.2 PROJECT PURPOSE

The purpose of this study is to investigate the feasibility of Federal assistance in protecting facilities along the Ocean Beach shoreline in the City and County of San Francisco from storm damage. - **EXPAND?**

1.3 STUDY AREA

The study area is located in the City and County of San Francisco. The County of San Francisco stretches 8.6 miles along the Pacific Coast from the southerly county line to the Golden Gate Bridge (Figure 1.3-1). Of this length, approximately 6 miles of coast consist of sandy beaches , and the remaining 2.6 miles are rocky headlands or bluffs. Ocean Beach extends from Fort Funston north to the Cliff House, a distance of approximately 3.6 miles. The Ocean Beach corridor comprises the area from the westerly curb of the Lower Great Highway to the ocean, and includes beach, dunes, seawalls, the Upper Great Highway, sewer transport boxes, parking lots, a recreational trail, and a landscaped linear park. Golden Gate Park is located along the northern third of the beach while the San Francisco Zoo is located in a major urban area and serves not only residents of the City, but also visitors from all over the world.

1.4 BACKGROUND INFORMATION AND NEED FOR THE PROJECT

Ocean Beach is located along the western boundary of the City and County of San Francisco, and serves as a buffer between the Pacific Ocean and the Great Highway and as a recreation area. Since the 1840's this strip of land has been used for transportation and recreation. Toward these purposes, various roadways and buildings have been constructed along the beach. Storms and erosion have continually threatened or destroyed these structures.

In the 1920's, the City of San Francisco planned to design and construct a concrete seawall along the entire Ocean Beach shoreline to protect the highway and to make a boardwalk/amusement tourist area. Economic conditions in the 1930's halted construction after only one mile of the project was completed. This seawall is known as the O'Shaughnessey Seawall, or esplanade, and it extends from north of Fulton Street to Lincoln Way.

The 665-foot long Taraval seawall was constructed in 1940 to protect the pedestrian underpass and the Great Highway. Sand deposition from natural processes has since buried this wall and modified dune habitat covers this reach.

In 1972, the City gave all of the land at Ocean Beach west of the Great Highway right-of-way to the Golden Gate National Recreation Area (GGNRA).

To alleviate pollution of the Pacific Ocean from the discharge of untreated effluent, the City constructed the Westside Sewer Transport Box under the Great Highway in 1983.

In March of 1988, construction of another seawall/promenade was begun to protect the Great Highway and sewer box between Noriega and Santiago Streets from major storms. This new seawall was completed in 1991.

Ocean Beach is subject to direct attack from waves approaching from the southwest to the northwest. High tides accompanied by large waves have caused recession of the dune escarpment along the central and southern portions of the beach. There is acute erosion of the beach and dunes at Moraga and Noriega Streets, Taraval to Ulloa Streets, and from south of Sloat Boulevard to the Fort Funston cliffs. This erosion threatens shoreline improvements, local infrastructure, natural resources, public property and recreational activities. Previous studies have shown that Ocean Beach has experienced shoreline recession and that major storms have eroded and will continue to erode sections of the beach and dunes.

3.0 RELATIONSHIP TO ENVIRONMENTAL PROTECTION STATUTES, PLANS, AND OTHER REQUIREMENTS

This EIS/EIR is a joint document designed to satisfy CEQA and NEPA requirements. The City and County of San Francisco is acting as the State Lead Agency under CEQA, and the U.S. Army Corps of Engineers, San Francisco District, is acting as the Federal Lead Agency under NEPA. CEQA guidelines contain clear authority for State and local agencies to prepare joint doucments with Federal agencies. NEPA regulations issued by the President's Council on Environmental Quality contain similar provisions. The relationship of each project alternative to environmental requirements (i.e., Federal, State, and local laws and regulations) are presented below and in Table 3.0-1. **???don't know if table?**

3.1 Federal Laws and Regulations

3.1.1 National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4341 *et seq.*)

This Act requires that environmental consequences and project alternatives be considered before a decision is made to implement a Federal project. NEPA established requirements for preparation of an EIS for projects potentially having significant environmental impacts. It establishes a process whereby the parties most affected by the impacts of a proposed action are identified and their opinions solicited. A DEIS is developed that presents sufficient information to evaluate the suitability of the proposed and alternative actions. This DEIS has been prepared on the proposed project, as discussed in Council on Environmental Quality regulations on implementing NEPA (40 CFR 1500-1508). The proposed action and several alternatives are evaluated in relation to their environmental impacts, and a tentative selection of the most appropriate alternative is made. All project alternatives presented in the EIS were developed in accordance with the goals specified in Section 101 of the Act. Distribution of the Notice of Intent (NOI) for the Draft EIS complied with NEPA requirements. A Notice of Availability (NOA), announcing that the DEIS can be obtained for comment, is published in the *Federal Register*. After the DEIS comment period, the comments are addressed, revisions are made to the DEIS, and the document is published as a Final EIS. The Corps is the lead agency under NEPA. This document fulfills the NEPA EIS requirements.

3.1.2 Coastal Zone Management Act of 1972, as amended, (16 U.S.C.1456 et seq.) **Need to change this to San Francisco Bay......what coastal plan....**

This Act requires that Federal activities affecting land or water resources located in the coastal zone be consistent to the maximum extent practicable with the federally-approved State coastal zone management plans. The State of California's Federally-approved Coastal Zone Management Plan for the waters and shoreline of Humboldt Bay is Humboldt County's

TABLE 3.0-1

COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

Environmental Requirement	*Project Alternative**
FEDERAL	
National Environmental Policy Act (NEPA)	FC
Coastal Zone Management Act	?
Clean Air Act	??
Clean Water Act	?
Archeological and Historic Preservation Act	?
Executive Order 11593, Protection & Enhancement of the Cultural Environment	?
National Historic Preservation Act	?
Abandoned Shipwreck Act	?
Fish & Wildlife Coordination Act	?
Endangered Species Act	?
Executive Order 11990, Protection of Wetlands	?
Federal Water Project Recreation Act	?
Executive Order, Exotic Organisms	? depends on NED

TABLE 3.0-1 (CONTINUED)

COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

Environmental Requirement	*Project Alternative**
STATE	
California Environmental Quality Act	?
Porter-Cologne Water Quality Control Act	?
California Endangered Species Act	?
California Coastal Act	?
LOCAL	
City and County of San Francisco General Plan?	?
Golden Gate National Recreation Area Master Plan	?

Legend:

FC = Full compliance -All requirements of the law, policy, or related regulations have been met.
PC = Partial compliance -Some requirements of the law, policy, or related regulations have not been met.
NC = Not in compliance - Use of the site would conflict with the law, policy, or related regulations.
NA= Not applicable -The law, policy, or related regulations do not apply to the preferred alternative.

"Humboldt Bay Area Plan/Local Coastal Plan (LCP)" (Humboldt County Planning Department 1982), which the California Coastal Commission (CCC) approved on October 14, 1982. CCC has jurisdiction over matters affecting the on and off shore areas within Humboldt Bay Harbor.

The proposed project's consistency with each applicable Coastal Zone Management Act policy/provision from the Humboldt County Local Coastal Plans (LCPs) is analyzed below:

> * *Coastal Provision 30211 - Development shall not interfere with the public's right of access to the sea where acquired through use, or legislative authorization, including, but not limited to, the use of dry sand and rocky coastal beaches to the first line of terrestrial vegetation.*

The proposed project will not be encroaching upon a public easement area since all operations, except disposal of unsuitable for unconfined aquatic disposal dredged material, will be conducted off-shore. The LP site is privately owned by the Louisiana-Pacific Corporation.

> * *Coastal Provision 30212 - Public access from the nearest public roadway to the shoreline, and along the coast shall be provided in new development projects where (1) it is inconsistent with public safety, military security needs, or the protection of fragile coastal resources, (2) adequate access exists nearby, or (3) agriculture would be adversely affected. Dedicated accessway shall not be required to be opened to public use until a public agency or private association agrees to accept responsibility for maintenance and liability of the accessway.*

The proposed project will be conducted off-shore, except for the disposal of unsuitable dredged material on an upland site. The LP disposal site is in private ownership and public access to the coast and Bay is allowed on property adjacent to the site.

> * *Coastal Act Provision 30230 - Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special or biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.*

The proposed project will temporarily impact water quality through an increase in sedimentation and turbidity in the immediate areas of dredging; dredged material disposal; and potential nearby areas depending on the currents and tidal flows. The Corps will obtain a Water Quality Certification from the North Coast Regional Water Quality Control Board for the disposal at HOODS, and proper permits for disposal at any upland site used for material unsuitable for unconfined aquatic disposal. The proposed project will be consistent with all requirements of the RWQCB and EPA. Extensive sediment sampling and testing has been performed to determine which sediments are suitable for unconfined aquatic disposal at HOODS, and which sediments are unsuitable for unconfined aquatic disposal. The proposed project has been designed to have the least impacts to the marine resources, and any species of biological and/or economic significance.

** Coastal Act Provision 30231 - The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored through, among other means, minimizing adverse effects of waste water discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface waterflow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.*

Please refer to "Coastal Provision 30230" for information related to the temporary impacts to water quality from dredging. The proposed project will not impact human health, and there are no adverse effects expected from the discharges of dredged material disposal, and subsequent decanting of the supernatant from either of the upland disposal sites and/or the HOODS site.

** Coastal Act Provision 30233 (a) - the diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible, less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects, and shall be limited to the following:*

(1) New or expanded port, energy, and coastal-dependent industrial facilities, including commercial fishing facilities.

The proposed project has been designed to be the least environmentally damaging alternative, and provides feasible mitigation/compensation measures which minimize any adverse environmental impacts (see Chapter 5.0 and associated sections).

** Coastal Act Provision 30233 - (b) Dredging and spoils disposal shall be planned and carried out to avoid significant destruction to marine and wildlife habitats and water circulation. Dredge spoils suitable for beach replenishment should be transported for such purposes to appropriate beaches or into suitable longshore current systems.*

The proposed project has been designed to have the least impacts to marine and wildlife resources and habitats, beaches and longshore current systems. The LP upland site has a long history as a disposal site, and the HOODS site is presently being permanently designated as a Section 102 site. Beach replenishment is not feasible due to environmental and economic constraints.

* Coastal Provision 30240 - (a) Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on such resources shall be allowed within such areas. (b) Development in areas adjacent to environmentally sensitive habitat areas and parks and recreation areas shall be sited and designed to prevent impacts which would significantly degrade such areas and shall be compatible with the continuance of such habitat.

The proposed project avoids environmentally sensitive habitat areas, since the majority of operations will be conducted off-shore. No significant impacts to any sensitive areas located within or adjacent to the proposed LP upland disposal are expected.

> * *Coastal Provision 30244 - Where new development would adversely impact archeological or paleontological resources, as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.*

The proposed project may adversely affect archaeological resources (submerged cultural resources at one dredging location and at three locations where ocean disposal of dredged sediments will take place. It is probable that avoidance of these resources can be achieved. If not, consultation with the State Historic Preservation Officer will be completed to determine reasonable mitigation measures for significant archaeological resources.

Based upon the above findings and analyses within this Consistency Determination and the EIS/EIR, the Corps has determined that the proposed project is consistent to the maximum extent practicable with the Federally-approved State's coastal management program, the California Coastal Plan, and the Federally-approved Coastal Zone Management Act, as required by 15 CFR 930 *et seq.* The Corps submitted the draft EIS/EIR which contains the Consistency Determination to the California Coastal Commission pursuant to Section 930.34 of the National Oceanic and Atmospheric Administration Federal Consistency Regulations. On February 8, 1995, the California Coastal Commission (CCC) concurred with Consistency Determination (CD-111-94), by a vote of 10 in favor and 0 opposed.
need to find out what Coastal Plan

3.1.3 Clean Air Act of 1977, as amended, (42 U.S.C. 7401 *et seq.*)

The objective of the Clean Air Act is to protect and enhance the quality of the Nation's air resources, and to promote public health and welfare and the productivity of its population. Under this Act, the administrator of the U.S. Environmental Protection Agency has established a set of Ambient Air Quality Standards, but the primary responsibility for the prevention and control of air pollution is left to the states. For areas where the Ambient Air Quality Standards are not met, the State must include measures in the State Implementation Plan which will achieve the standards as expeditiously as possible.

Section 118 (a) of the Clean Air Act provides that all Federal agencies, including the Corps of Engineers, are subject to all Federal, State, and local requirements regarding the control and abatement of air pollution in the same manner and to the same extent as any non-governmental entity. This provision specifically applies to both substantive and procedural requirements. Section 176 (c) of the Act provides that no Federal agency shall engage in any activity which does not conform to an approved State Implementation Plan. These requirements will be met by obtaining any necessary permits from the State of California prior to construction. Air quality impacts are addressed in detail in **Section ????** of this EIS/EIR.

In addition, the 1990 CAA required Federal actions to complete an analysis of whether the project would conform to the requirements of the most recent Federally-approved State Implementation Plan (SIP). Final guidelines on how to perform the conformity analysis were recently promulgated by the EPA (EPA 1993). Since the project area is located in a non-attainment area, a project conformity determination was performed in the air quality analysis conducted on the Ocean Beach Storm Reduction Study.

3.1.4 Clean Water Act of 1977, as amended, (33 U.S.C. 1251 *et seq.*)

The objective of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. Specific sections of this Act control the discharge of pollutants and wastes into aquatic and marine environments.

Section 404(b) of the Clean Water Act, as amended in 1977, requires that the Corps of Engineers evaluate the impact of the discharge of dredged or fill material into waters of the United States in order to make specified determinations and findings. Subpart A, Section 230.1 (c) of the Section 404(b)(1) guidelines states the following: "Fundamental to these guidelines is the precept that dredged or fill material should not be discharged into the aquatic ecosystem, unless it is demonstrated that such a discharge will not have an unacceptable adverse impact either individually or in combination with known and or probable impacts of other activities affecting the ecosystems of concern." Although Section 401 and 404(b) of the CWA apply, by their own terms, only to applications for Federal Permits, the Corps has made a policy decision to apply them to their own projects. This policy is set forth in Corps regulations 33 CFR Part 336. Section 336.1(a) of that regulation states "Although the Corps does not process and issue permits for its own activities, the Corps authorizes its own discharges of dredge or fill material by applying all applicable substantive legal requirements, including public notice, opportunity for public hearing, and application of the Section 404(b)(1) guidelines".

Since the placement of sand above the high tide line would not directly affect the territorial waters of the United States, these guidelines would not apply if the sand supply for beach nourishment was trucked in. However, if sand for dune nourishment is pumped from a barge onto the beach, Section 404(b) guidelines would be applicable to any potential effluent (runoff) from the dune nourishment effort, and its effects on the waters of the Pacific Ocean???? An evaluation, as specified in the Section 404(b)(1) guidelines, has been included in this EIS/EIR as **Appendix A.** When submitted to Congress, this procedure will satisfy Section 404 (r) of the Act in lieu of issuing a public notice, and obtaining a State water quality certification. The findings of the Section 404(b)(1) Evaluation indicated that the proposed placement of approximately **?????** cubic yards of **sandy material for dune nourishment at Ocean Beach** will be in full compliance with this Act.

NEED TO KNOW ALTERNATIVE FIRST!!! took Section 319 of CWA out of discussion

Plus where is "Ocean Plan"

3.1.5 Archeological and Historic Preservation Act of 1974, (16 U.S.C. 469 *et seq.*)

The Archaeological and Historic Preservation Act (AHPA) amended the Reservoir Salvage Act of 1960. The AHPA provides for the preservation of historic and archaeological data that might otherwise be lost or destroyed as a result of any Federal construction project or Federally licensed or assisted undertaking. The AHPA authorizes the lead Federal agency of a project, or the Secretary of the Interior, to undertake recovery or preservation of such data. Federal project funds, up to one percent of the project cost, may be used, or the agency may request the Secretary of the Interior to conduct the desired measures.

The Corps has identified **what # shipwrecks - 28????** locations of potential cultural resources during the course of planning studies. These submerged potential sites which may warrant data recovery or protection are situated outside the areas that are **proposed for dune nourishment**. Avoidance of impacts to cultural resources, which is supported by the technical information generated thus far, gives the Corps full compliance with the AHPA. In the event that avoidance cannot be achieved due to project changes, and archaeological and historic data would need to be recovered, such data recovery would be implemented to achieve full compliance.

3.1.6 Executive Order 11593, Protection and Enhancement of the Cultural Environment, (36 C.F.R. 8921, May 13, 1971)

This Executive Order requires Federal agencies to (1) inventory the cultural resources on lands under their jurisdiction, (2) outline measures to actively protect and preserve these cultural resources, (3) nominate to the National Register of Historic Places those inventoried cultural resources

considered significant, and (4) initiate measures to ensure that their policies contribute to the protection and preservation of non-federally owned cultural resources. **No cultural resources have been identified in the study area. The proposed alternatives are therefore in full compliance with this Executive Order.**

3.1.7 National Historic Preservation Act of 1966, as amended, (16 U.S.C. 470 *et seq.*)

The National Historic Preservation Act (NHPA) established the National Register of Historic Places, a listing of sites, districts, structures and objects significant in American history, architecture, archaeology, engineering and culture. Archaeological sites, historic buildings and other cultural resources may be determined eligible for inclusion in the National Register on the basis of local, regional, state or national significance. Section 106 of the NHPA requires Federal agencies to "take into account" the effects of a proposed project on such sites and structures which are listed, or which have been determined eligible for listing, on the National Register. The taking into account of effects involves (a) consultation between the Corps and the State Historic Preservation Officer to determine whether identified sites or structures in the Area of Potential Effect (APE) are National Register quality and to analyze possible project-induced impacts and (b) affording the Advisory Council on Historic Preservation an opportunity to comment on the consultation findings. The Corps must satisfy the Section 106 provisions prior to the expenditure of Federal funds for construction of a proposed project.

The Corps has identified **how many ?????** locations offshore in the Pacific Ocean that may contain submerged cultural resources. These potential sites are situated outside the APE for either **dune nourishment or ????**. This information is the basis for the conclusion that no historic properties will be affected by the proposed undertaking. Presently, the recommended plan is in partial compliance with the NHPA. Full compliance with the NHPA would follow completion of the Section 106 consultation with the SHPO and (if necessary) comments from the Advisory Council on Historic Preservation.

3.1.8 Abandoned Shipwreck Act of 1987, (43 U.S.C. 2101 *et seq.*)

This Act creates Federal authority to transfer ownership of abandoned shipwrecks to the state on whose submerged lands the wreck is located. The Department of the Interior administers the act through regulations issued by the National Park Service. Exceptions are those shipwrecks on public lands of the United States, which will be kept in Federal ownership, and those on Indian lands, which will be the property of the Indian tribe owning the land rights. The Act provides Federal protection to any shipwreck which meets the criteria for eligibility for inclusion in the National Register for Historic Places. Should any of the submerged cultural resources identified through research and remote sensing be found eligible for inclusion in the National Register, the Corps would achieve full compliance by consultation with the State Historic Preservation Officer and selection of appropriate protection measures.

Anything on the 28 shipwrecks??? - sensing, etc.....

3.1.9 Fish and Wildlife Coordination Act of 1958 (16 U.S.C. *et seq.*)

The Fish and Wildlife Coordination Act requires that whenever any body of water is proposed or authorized to be impounded, controlled (i.e., diverted), or modified (i.e., deepened), the lead Federal agency must consult with the U.S. Fish and Wildlife Service (FWS); with the State agency exercising administrative authority over wildlife resources (in California, the California Department of Fish and Game); and for projects affecting marine fisheries, the National Marine Fisheries Service (NMFS). Section 662(b) of the Act requires the lead Federal agency to consider FWS and other agencies' recommendations. The recommendations may address wildlife conservation and development, any damage to wildlife attributable to the project, and any measures proposed for mitigating or compensating for these damages. The reports and recommendations of FWS must become an integral part of the reports for engineering surveys when submitted to Congress for authorization. The Act is applicable to the Corps' evaluations of consistency with the CWA Section 404 requirements. The Corps is coordinating with the FWS, which has **prepared a Draft Fish and Wildlife Coordination Act Report (CAR) on the proposed project (see Appendix B).**

3.1.10 Endangered Species Act of 1973, as amended, (16 U.S.C. 1531 *et seq.*)

The Endangered Species Act protects threatened and endangered species by prohibiting Federal actions that would jeopardize the continued existence of such species or that would result in the destruction or adverse modification of any critical habitat of such species. Section 7 (a) of the Act requires consultation with the Secretary of the Interior (through the U.S. Fish and Wildlife Service) and/or the National Marine Fisheries Service (NMFS), prior to project implementation, to determine if any endangered or threatened species may be present in the area of a proposed Corps action, and to ensure that the action will not jeopardize the continued existence of a species or destroy or adversely modify the designated critical habitat of such species. During the project planning process, the FWS and NMFS evaluate the potential impacts of all aspects of the project on threatened or endangered species. Their findings are contained in letters that provide an opinion on whether a project will jeopardize the continued existence of endangered species or modify critical habitat. Such letters must provide reasonable and prusent alternatives, if any, that will avoid jeopardy. This DEIS/EIR is the Biological Assessment required by the Act. Full compliance of the reaches of shoreline protection areas at Ocean Beach with this Act assumes that this DEIS/EIR will suffice as a Biological Assessment. Informal consultation with the FWS regarding any endangered species that may be present at the upland site has been initiated in conjuction with the DCAR described in the preceding section, and the Corps will initiate formal consultation as appropriate, based on FWS review and comment on the **shoreline protection** alternatives. The Corps Biological Assessment (**see Section ?????**) concluded that the proposed project would not impact any threatened, endangered species and there would be no unmitigable impacts associated with the proposed project.

3.1.11 Executive Order 11990, Protection of Wetlands (42 FR 26961, May 25, 1977)

Under this Executive Order, Federal agencies are directed to provide leadership and take action to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial qualities of these lands. Federal agencies are also required to avoid

undertaking or providing support for new construction located in wetlands unless (1) no practicable alternative exists and (2) all practical measures have been taken to minimize harm to wetlands. **All of the project alternatives are located seaward of the MLLW, therefore are in full compliance with this Executive Order.(true?)** Each of the **dune nourishment or seawall reaches** have been designed to minimize impacts on wetlands to the extent practicable. Any unavoidable wetland losses would be fully mitigated through habitat compensation measures.

3.1.12 Federal Water Project Recreation Act (Public Law 89-72)

This Act, which was passed by Congress in 1965, established the Federal policy that any investigation or plan for any Federal navigation, flood control, reclamation, hydroelectric, or multi-purpose water resource project must give full consideration to the opportunities for outdoor recreation and for fish and wildlife enhancement. Wherever any such project can reasonably serve either or both of these purposes, it must be constructed, operated, and maintained accordingly. **The proposed project provides some recreational amentities as project features such as boardwalks and educational signs to inform the public about the importance of the dune restoration area. Therefore, the Ocean Beach Storm Reduction Study is in compliance with this Act.**

3.1.13 Executive Order, Exotic Organisms, May 24, 1977

what is this act? need a definition....

3.2 State of California Laws and Regulations

3.2.1 California Environmental Quality Act (CEQA) and Implementing Guidelines (June 1986, Public Resources Code Section 21001 *et seq.*)

This Act requires that State and local agencies prepare an Environmental Impact Report (EIR) for any project they propose to carry out or approve which may have a significant effect on the environment. As a Federal agency the Corps of Engineers is subject to the requirements of NEPA. However, the Corps is incorporating the CEQA requirements for the local project sponsor, the City and County of San Francisco, into this joint EIS/EIR. CEQA encourages State and local agencies to use Federal EIS's as State EIR's wherever possible. Distribution of the Notice of Intent (NOI) and the Notice of Availability (NOA) for the Draft EIS/EIR complied with NEPA/CEQA notification requirements, respectively.

In addition, CEQA establishes requirements similar to those of NEPA for consideration of environmental impacts and alternatives, and for preparation of an EIR prior to implementation of applicable projects. CEQA, however, requires that significant environmental impacts be mitigated to a level of insignificance, or to the maximum extent feasible. If full mitigation is not feasible, the State lead agency must make a finding of overriding considerations before approving the project. The proposed action falls under the purview of CEQA. This document fulfills the

CEQA EIR requirement. Responsible agencies (public agencies other than the lead agency that have responsibility for carrying out an approved project) include the California Coastal Commission, **who ???? -North Coast Regional Water Quality Control Board?, State Lands Commission, and the Bay Area Air Quality Management District.**

3.2.2 Porter-Cologne Water Quality Control Act of 1966 (California Water Code Sec. 13000 *et seq.*; CCR Title 23, Chapter 3, Subchapter 15)

The Porter-Cologne Act is the primary state regulation that addresses water quality. The requirements of the Act are implemented by the State Water Resources Control Board (SWRCB) at the State level and, at the local level, Regional Water Quality Control Board (RWQCBs). Under the direction of the SWRCB, the RWQCBs carry out planning, permitting, and enforcement activities related to water quality in California. The **who has jurisdiction ????North Coast Regional Water Quality Control Board** has jurisdiction over Ocean Beach. The Act provides for waste discharge requirements and a permitting system for discharges to land or water. The Act also provides plans to identify beneficial uses of water resources and to implement appropriate water quality control measures. Full compliance of the **Ocean Beach shoreline protection reaches** with this act assumes that the **who? RWQCB** accepts compliance with the Clean Water Act.**if barged in????**

3.2.3 California Endangered Species Act of 1984 (Fish and Game Code Section 2050, *et seq.*)

The California Endangered Species Act provides for the recognition and protection of rare, threatened, and endangered species of plants and animals. The Act requires State agencies to consult with the California Department of Fish and Game (CDFG) to ensure that State-authorized or funded actions do not jeopardize the continued existence of a listed species. The Act prohibits the taking (collection, killing, or injury, whether intentional or accidental) of listed species without authorization from the CDFG. CDFG may authorize the taking of a listed species through a Memorandum of Understanding that establishes the extent of take permitted by CDFG and sets forth the required mitigation.

3.2.4 California Coastal Act of 1976 (Public Resources Code Section 3000 *et seq.*)

This Act establishes the State Coastal Zone Management Plan (CZMP), which has been approved by the U.S. department of Commerce. All Federal actions that affect the coastal zone must be determined to be as consistent as practicable with this plan (see CZMA above).

3.3 Local Laws and Regulations

3.3.1 County of Humboldt General Plan **City and County of San Francisco General Plan???**

The General Plan 2020 (Baruth and Yoder 1969) for the Mid-Humboldt County Urban Planning Program addresses various aspects of preservation and development for Humboldt County. Relevant topics include: short-range and long-range land use development (industrial, commercial, and agricultural); recreation; natural environment; transportation; population; and economics. Compatibility with the General Plan is addressed in the corresponding sections of this EIS/EIR.

The General Plan states that "The Entrance Bar is considered to be treacherous and if weather conditions are too bad, the pilots do not bring the ships in or out. With expected growth of the total tonnage of waterborne commerce in Humboldt Harbor, these weather conditions may preclude any other way of handling cargo in the channels. The other ways may have included off-shore loading and unloading of bulk or general cargo. With the expected growth of Humboldt Harbor and increase of general cargo, more use of the development of containerization is expected to be made in the future, which needs loading and unloading facilities". The General Plan also states that "concurrent with construction of a commercial port facility, the Entrance Channel and North Bay Channel should be deepened and widened to insure full utilization by newer-type container vessels". The project alternatives have been designed to be compatible with the General Plan, and with full consideration of the importance of preserving Humboldt Bay's fish and wildlife resources.

3.3.2 Humboldt Bay Master Plan **Any Master Plan? - GGNRA???**

The Humboldt Bay Master Plan (Koebig and Koebig 1975) (Ordinance No. 7; adopted by the Humboldt Bay Harbor, Recreation, and Conservation District Board of Commissioners (Board) on June 13, 1975) addresses planning objectives for the future of Humboldt Bay. The jurisdictional authority of the Humboldt Bay Harbor, Recreation, and Conservation District for the implementation of this Master Plan for Humboldt Bay is limited to Humboldt Bay up to the mean higher high water (MHHW) except for Indian, Woodley, and Daby Islands where the District jurisdiction is up to the mean high water level. Implementation of the Master Plan on the adjacent upland areas around the Bay will require cooperative efforts with other local jurisdictions.

Water and land use planning objectives (Article II; Section 2) listed in the Master Plan for Humboldt Bay include the following:

(a) Conservation Water - Use of Conservation Water areas shall generally be limited to natural resources habitat, wildlife refuges, mariculture, public access, and scenic vistas.

(b) Development Water - Use of Development Water areas shall generally be limited to access for commercial and industrial users and to improved and maintained channels.

(c) Public Open Space Land - Use of Public Open Space Land areas should generally be limited to natural resources habitat, wildlife refuges, recreation, public access, and scenic vistas.

(d) Agriculture Land - Use of Agriculture Land should generally be limited to crop and livestock production.

(e) Service/Commercial land - Use of Service/Commercial Land should generally be limited to commercial activities that are dependent on proximity to the waterfront, and might include enterprises such as restaurants and specialty shops.

(f) Port-Related Industrial Land - Use of Port-Related Industrial Land areas should generally be limited to waterfront developments requiring direct access to deepwater shipping channels.

(g) Water-Related Industrial Land - Use of Water-Related Industrial Land areas should generally be limited to waterfront developments requiring direct access for shallow draft vessels or requiring industrial cooling water.

(h) Nonwater-related Industrial Land - Use of Nonwater-Related Industrial Land areas should generally be limited to waterfront developments dependent upon not requiring direct access to the waterfront.

Article IV (Operational Policies) addresses "Navigation", in Section 2, and "Dredging, Diking, and Filling", in Section 8, respectively. The Master Plan requires that maintenance and improvement of existing navigational channels be supported and encouraged (through maintenance and construction of facilities), and dredging shall be limited to maintenance and improvement of navigational channels and areas designated for water-related developments. Section 9 (Environmental Quality) in the Master Plan states that maintenance and improvement of environmental quality shall be primary objectives for the use and development of all ares of Humboldt Bay, and not just those areas designated as "Conservation Water" and "Public Open Space Lands". The project alternatives for the proposed project have been designed to be generally compatible with the Humboldt Bay Master Plan.

3.4 Non-Applicable Requirements

The following laws and policies were examined and found not to be applicable to the alternatives discussed in this DEIS/EIR:

Estuary Protection Act, (16 U.S.C. 1221 et seq.) - This Act requires the consideration of estuaries and their natural resources by Federal agencies for all project plans affecting them. The proposed project will not affect any estuary, therefore, this Act is not applicable to the proposed project.

Rivers and Harbors Act of 1899, (33 U.S.C. 401 *et seq.*) - This Act is not applicable to the proposed project because the proposed project does not affect a navigable waterway.

Watershed Protection and Flood Prevention Act, (16 U.S.C. 1001 *et seq.*) - This Act authorizes certain Soil Conservation Service activities and has no requirements pertaining to Corps projects. In addition, the proposed project is not located on or near a floodplain, so this Act is not applicable.

Wild and Scenic Rivers Act, (16 U.S.C. 1271 *et seq.*) - There are no designated rivers near the study area.

Council on Environmental Quality Memorandum on Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the National Environmental Policy Act, August 11, 1990 - There are no farmlands in the study area.

State of California Wetlands Policy - This State policy recognizes the value of marshlands and other wetlands. The proposed project will not affect any marshlands or wetlands, therefore, this policy is not applicable to the proposed project.

State Lands Commission Policies - The State Lands Commission (SLC) is responsible for administration of State public trust lands in coastal waters (within a 3-mile territorial limit) and other tidal and submerged areas. The SLC reviews dredging projects for compliance with CEQA. The SLC is not expected to have any jurisdictional interests in any of the Ocean Beach shoreline protection reaches for the proposed project.

3.5 Permits or Approvals Required to Implement the Selected Plan

Permit/Approvals to be Obtained by the Corps of Engineers

- ☼ Consistency Determination concurrence from:

  - The California Coastal Commission for the placement of approximately **?????** **cys** of sandy material for dune nourishment activities at the three shoreline protection reaches at Ocean Beach.

Permits/Approvals to be Obtained by the City and County of San Francisco

- ☼ From the RWQCB:

  - **Waste discharge permit and any needed NPDES permit for disposal of sandy material at the three shoreline protection reaches at Ocean Beach.**

- ☼ **Any necessary construction easements and fees associated with dune nourishment activities at Ocean Beach??? or protection?**

APPENDIX C6

FY 1996 Scope of Work for the FWS's Draft & Final Coordination Act Report for the Ocean Beach Storm Damage Reduction Study

OCEAN BEACH STORM DAMAGE REDUCTION STUDY
SCOPE OF WORK
FY 96

Study Manager:	Robert Nielsen	415-744-3362
Environmental Manager:	Tamara Terry	415-744-3129

Objectives: To provide draft and final Coordination Act Reports (CAR's) describing the effects of the placement of a Taraval-type seawall in Reach 3 for the prevention of storm damage to the Great Highway infrastructure, on fish and wildlife resources within the project area, and to recommend any potential mitigation actions as may be appropriate.

Project Description: Ocean Beach is subject to direct attack from waves approaching from the southwest to the northwest. High tides accompanied by large waves have caused recession of the dune escarpment along the central and southern portions of the beach. There is acute erosion of the beach and dunes at Moraga and Noriega Streets, from Taraval to Ulloa Streets, and from south of Sloat Boulevard to the Fort Funston cliffs. This erosion threatens shoreline improvements, local infrastructure, natural resources, public property and recreational activities. Previous studies have shown that Ocean Beach has experienced shoreline recession and that major storms have eroded and will continue to erode sections of the beach and dunes.

The project alternatives would include one structural "Taraval-type" seawall alternative and the No-Action Alternative (The name "Taraval-type" seawall refers to an existing structure near the end of Taraval Street which was constructed by the City of San Francisco in the 1940's, andwas subsequently buried by sand, and is presently not visible). The project is located in Reach 3 which starts approximately 80 feet north of Sloat Boulevard, and extends 2,680 feet to the Fort Funston Bluffs, and includes the National Park Service's north parking lot, and the two south parking lot areas.

Reach 3 is characterized by a narrow band of dunes with a high potential for dune retreat. The proposed "Taraval-type" seawall would be approximately 2,680 feet long, and have a crest elevation of 13 feet mean lower low water (MLLW). The wall will be located along the western slope of the existing parking lot areas. The wall would be constructed of steel sheetpile. The sheetpile wall would have concrete cap approximately 2.5 feet wide by 3 feet high. The design of the wall will anticipate overtopping, and a rock toe will be placed for overwash protection along the toe of the excavated slope, approximately 30 feet eastward of the sheetpile wall.

After construction, the wall would be covered with excess material from excavation. It is expected that the seawall will remain buried during part of the year, and will be partially exposed during part of the year - depending on sand transport onto and off of the beach in Reach 3. This exposure will vary seasonally. The beach berm elevation can be as low as 10 feet MLLW, and the beach may lower to 6 feet above MLLW during winter storm periods. When local scour

depths are at 0 feet MLLW, approximately 3 to 6 feet of wall may be visible. Stairways would be located at intervals along the seawall to allow beach access while the wall is exposed. The proposed construction of this "Taraval-type" seawall would temporarily impact and close off the south parking lot during the construction period.

Previous coordination activities:

Planning Aid Letter	Nov 1990	Reconnaissance study alternatives

Corps-furnished data: Ocean Beach Storm Damage Reduction Reconnaissance Study dated March 1992, with accompanying Environmental Assessment. Updated design information for project structural alternative.

Statement of Services:

1. Review pertinent data and coordinate with the California Department of Fish and Game and the National Marine Fisheries Service to fully describe the importance of local fish and wildlife resources. As appropriate, discuss scarcity, abundance, irreplaceability, and/or uniqueness.

2. Identify project impacts to significant fish and wildlife resources. These impacts include, but are not limited to, impacts to species, species life stages, species life requisites, and species diversity considerations. Describe impacts by traditional analysis methods. Specify the location, timing, and duration of these impacts. Describe the boundaries within the project area where significant impacts will occur.

3. Identify resource categories and potential mitigation recommendations. Identify modifications of the study alternative that will address fish and wildlife-related planning objectives, including project features recommended for fish and wildlife conservation and enhancement. Provide mitigation recommendations and costs for this alternative as may be appropriate, including identification of specific methods and sites to be used for any habitat compensation measures. Describe the benefits which would justify the recommended mitigation or enhancement measures.

4. For the study alternative, perform a habitat analysis to quantitatively compare the effects of project features and mitigation measures on habitat values. Mitigation measures shall be evaluated incrementally, with a minimum of three mitigation increments for the alternative. The habitat assumptions and mitigation increments shall be agreed upon by the Fish and Wildlife Service and the Corps prior to the habitat analysis.

5. Prepare both draft and final Coordination Act Reports (CAR's).

Checkpoints:

Checkpoint 1	15 October 1995	Corps provides description of alternatives
Checkpoint 2	15 December 1995	FWS provides preliminary draft CAR
Checkpoint 3	2 January 1996	Corps provides comments on preliminary draft CAR
Checkpoint 4	11 March 1996	FWS provides draft CAR
Checkpoint 5	1 July 1996	Corps requests final CAR
Checkpoint 6	1 August 1996	FWS provides final CAR

Funds Available: $ 25,000

Assistant Regional Director   Date
Ecological Services
U.S. Fish and Wildlife Service

APPENDIX - D

GEOTECHNICAL ANALYSIS

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

OCEAN BEACH
GENERAL INVESTIGATIONS FEASIBILITY
STORM DAMAGE REDUCTION STUDY
CITY AND COUNTY OF SAN FRANCISCO

GEOTECHNICAL APPENDIX

Prepared by
U.S. Army Engineer District, San Francisco
Corps of Engineers
San Francisco, California

September 1996

GEOTECHNICAL APPENDIX
OCEAN BEACH FEASIBILITY STUDY

GEOLOGY

The study area lies on the western shore of the San Francisco Peninsula, south of Golden Gate Park and north of Fort Funston. The San Francisco Peninsula is formed by the northern end of the Santa Cruz Mountains, and lies within the Coast Range physiographic province of California. The study area contains three reaches that are the focus of this study. The first reach is the northern reach, approximately 870 feet in length from the center line of Moraga Street to 180 feet south of Noriega Street (the northern end of the New Great Highway Seawall/Promenade). The second reach is the middle reach, approximately 300 feet in length south from the southern end of the New Great Highway Seawall/Promenade. The southern end of the New Great Highway Seawall lies approximately 200 feet north of the center line of Santiago Street. The third reach is the southern reach which extends south from 80 feet north of Sloat Boulevard for approximately 2,680 feet to the Fort Funston bluffs. The third reach encompasses the north, middle, and south parking lots of the National Park Service. The stratigraphy in each reach consists of, from youngest to oldest, placed fill, dune sands, Colma Formation, Merced Formation, and bedrock. Each of the stratigraphic units will be briefly described in the following paragraphs.

The placed fill comprises a part of the surficial soil deposits. The fill is mainly reworked dune sands placed during the construction of the Great Highway in the 1920's and again during its relocation in 1988-1989. The Great Highway was relocated as a result of the construction of the New Great Highway Seawall/Promenade and the Westside Outfall Sewer Transport Pipe. Subsurface investigation in 1985, prior to the construction of the New Great Highway Seawall/Promenade, indicated that the placed fill in the northern reach of the study area was 10 to 12 feet thick; in the middle reach, 7 to 14 feet thick; and 16 feet thick at Wawona Street. South of Sloat Boulevard there is no known data on the thickness of placed fill.

The sand dunes are composed of windblown sand, fine to medium-grained and poorly graded. The source of the dune sand is from Ocean Beach. The sand from the beach is generally yellowish brown to light gray and speckled with a few white shell fragments and abundant dark-gray, green, and brown grains. The sand dunes are primarily of Holocene to recent in age, although they may extend into very late Pleistocene time.

A subsurface exploration program conducted by Allstate Geotechnical Services (1985) indicated that the dune sand in the northern reach of the study area may range in thickness from 16 to 20 feet. The thickness of dune sand in the middle reach may range from 20 to 26.5 feet. At Wawoma Street the thickness of dune sand is 13 feet. South of Sloat Blvd. the thickness of dune sand may be even greater. According to the Allstate report, a washout occurred through the dune field in 1852 in the vicinity of Fleishhacker Zoo and Sloat Blvd. from unusually high water levels in Lake Merced. The washout, probably due to the sudden outpouring of flood water from Lake Merced, deepened the pre-existing outlet and extended it to the ocean. The washout was later filled by dune sand deposits during the period between 1852 and 1906. The Allstate report indicated that an approximate location of the washout was able to be determined from topographic maps. The dunes are underlain by the Colma Formation; the contact is generally above 0.0 feet mean lower low water (MLLW). The exploration program did not extend into the southern reach.

The Colma Formation consists of a complex deposit of coastal and estuarine deposits composed predominantly of sand. According to Schlocker (1974): "The Colma Formation appears to have been deposited mostly by water and gravity, and to a lesser extent, by wind in a variety of coastal environments." The Colma Formation was deposited probably during the late Pleistocene perhaps during the Sangamon Interglacial Stage, the last period of very high sea level stands prior to the Holocene. The Colma Formation occurs both beneath the dune sands and inland at elevations up to about 550 feet above MLLW. The Colma has probably experienced some tectonic uplift after being deposited. It is predominantly a poorly graded, fine to medium grained, friable sand deposit with small to moderate amounts of silt and clay. Beds and lenses of silty clay to clayey sand up to 12 feet in thickness were found during the 1985 subsurface investigation both to the north and south of the northern reach and south of the middle reach. At Wawona Street a 3-foot-thick layer of dark brown, very stiff peat was found near the top of the Colma Formation. The Colma Formation is generally light brown to orange in color and has horizontal or nearly horizontal bedding and cross bedding. The beds range from 1 inch to 3 inches thick (Scholcker, 1974). The Colma Formation is considered to be one of the sources of sand to Ocean Beach and thus to the sand dunes. It overlies the Merced Formation; however, due to the lack of deep borings at the site the depth to the Colma-Merced contact is not known. The Colma Formation is believed to have been deposited on the eroded surface of Merced Formation.

The Merced Formation consists of poorly cemented sand of

Pliocene to early Pleistocene age. The Merced Formation is composed of sand grains of similar size and mineralogical content as the Colma Formation; it is considered to be the most likely source of much of the Colma Formation (M.G. Bonilla, oral communication, 1961, in Schlocker, 1974, page 71). The Merced Formation is believed to unconformably overlie bedrock of the Jurassic to late Cretaceous Franciscan Complex. Although no borings have been drilled to bedrock in the study area, the depth to bedrock is believed to be in the range of 350 to 450 feet, based upon bedrock-surface maps of Julius Schlocker (1961) and M.G. Bonilla (1964).

SEISMICITY

The San Francisco Peninsula lies within a highly active seismic region of California. It lies within the Seismic Zone 4 of the California, Arizona, and Nevada Seismic Zoné Maps and adjacent to the highly active San Andreas fault. The study area lies approximately 2 miles northeast of the trace of the San Andreas fault, 5.5 miles northeast of the Seal Cove - San Gregorio fault, and 16 miles southwest of the active Hayward fault which is a part of the San Andreas fault system.

The San Andreas fault has been divided into segments for the purpose of estimating the probabilities of large earthquakes on the fault in the U.S. Geological Survey (U.S.G.S.) Publication "Probabilities of Large Earthquakes in the San Francisco Bay Region, California", Circular 1053 (1990). Based upon this circular the San Andreas fault segment off shore of the site is a part of the North Coast segment with an expected recurrence rate of approximately 250 years and a 2-percent probability of a Richter magnitude (M) 7 or greater occurring in the next 30 years. However, the site is approximately 15 miles from the San Francisco Peninsula segment which has a 23-percent probability of generating a $M \geq 7$ earthquake within the next 30 years. In addition, the site is 16 miles from the northern segment of the Hayward fault which has a probability of 28-percent of generating a $M \geq 7$ earthquake within the next 30 years (U.S.G.S. Circular 1053).

The Seal Cove - San Gregorio fault has been assigned a maximum credible earthquake (MCE) magnitude of 7.5 based upon a rupture length equal to one-half of its 125 mile trace length, using the rupture length to magnitude relationship of Mark and Bonilla (1977). The MCE of M=7.5 for the Seal Cove - San Gregorio fault was used by Kiremidjian and Shah (1978) in their graph of return period in years for earthquakes $\geq$ M versus Richter magnitude; they indicated that the recurrence rate for M=7.5 is approximately 390 years. Since the length of the time interval is not known since the last event of $M \geq 7.0$, estimating the

probability of occurrence during the project life is very difficult. However, the probability of recurrence increases as stresses continue to build up since the time of its last occurrence. The following tabulation summarizes the seismicity of the fault zones closest to the study area.

FAULT ZONE	DISTANCE FROM STUDY AREA	MCE MAGNITUDE	MEAN PEAK ACCELERATION
San Andreas North Coast Seg.	2 mi	8.3	1.62g
San Andreas Peninsula Seg.	15 mi	7.5	0.40g
Seal Cove - San Gregorio	5.5 mi	7.5	0.93g
Hayward	16.2 mi	7-7.5	0.26-0.41g

Accelerations were calculated from the equation for a hard site as developed by Krinitzsky, Chang, and Nuttli (1987).

The project site was determined to be a "hard site" based upon the criteria presented by Krinitzsky and Chang (1987) for sand and silt.

According to U.S.G.S. Open File Report, OF 82-1033, titled "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock" there is a 10-percent probability that bedrock acceleration of approximately 0.7g will be exceeded during a 50 year interval. Also there is a 10-percent probability that bedrock acceleration of approximately 0.55g will be exceeded in 10 years. The corresponding return period for 0.7g is 475 years and for 0.55g, 95 years. The probability that 0.55g will be exceeded during the 50-year project life is 41 percent. By interpolation, there is approximately a 20-percent chance that an acceleration 0.63g will be exceeded within the 50-year project life.

INVESTIGATION

Investigation for the study area consisted of a site visit and a review of a geotechnical report titled "Geotechnical Investigation, New Great Highway Seawall" by Allstate Geotechnical Services in association with Woodward-Clyde Consultants (October 1985). The above geotechnical report provided data on subsurface soil conditions, geotechnical

findings, conclusions, and recommendations for design and construction of the proposed seawall. Thirty borings were drilled between 13 May and 6 June 1985 for the aforementioned report. The logs of these borings and the laboratory test results are included in Attachment 1. Three of these borings were drilled within the northern reach of the study area, and a boring was drilled within 160 feet of each end.

The Allstate report indicates that one boring was drilled in the middle reach opposite the Santiago intersection by Harding Lawson Associates at a previous time. A boring was drilled by Allstate within 80 feet of the northern end of the reach and another within 370 feet of the southern end of the reach.

For the third reach, very little subsurface geotechnical data was found along the beach west of the parking lots. Several borings have been performed for the City and County of San Francisco east of the parking lots leading to the construction of the Westside Sewer Transport Box. The sewer transport box is located under the northbound lanes of the Upper Great Highway. Those borings are sufficiently remote from the potential alignments of the seawall wall alternatives so as not to provide the necessary site-specific subsurface information required for the determination of foundation conditions. Although it appears that one boring was performed through the beach along the alignment of the later constructed Southwest Ocean Outfall Pipe (at the southern end of Reach III), the data presented in the boring log is too general for use in detailed design.

The borings within the northern reach of the study area range from 44.5 feet to 60 feet in depth. The borings within the middle reach of the study area range from 59.5 feet to 71.5 feet in depth. The boring at Wawona Street reached a drilled depth of 79.5 feet. The borings were advanced using rotary - wash boring equipment. The soil material was sampled on approximately 5-foot intervals in the upper 35 to 37 feet of each boring, and on approximate 10-foot centers below. Samples were taken using a 2-inch O.D. Standard Penetration Testing (SPT) sampler without liners, a 2 1/2-inch O.D. Modified California sampler, and a 3-inch O.D. Pitcher Barrel sampler. The SPT sampler was advanced by driving it with a 140-pound donut hammer free falling 30 inches. The Modified California sampler, with liners, was advanced using a 400-pound "Jars-Type" hammer falling 18 inches. Blow counts were recorded; those blow counts for the Modified California sampler were converted to "Equivalent Standard Penetration Blow counts" as shown on the boring logs in the geotechnical report.

Soils. The soils encountered are predominantly a medium to fine-grained sand, ranging from poorly graded to clayey sand. The consistency ranges from medium dense to very dense. The artificial fill, for the full reach investigated by the Allstate geotechnical report, ranges in dry density from 92 to 100 pounds per cubic foot (p.c.f.) and a moisture content (MC) of 2 to 15 percent. The dune sand ranges in dry density from 93 to 113 p.c.f. and a MC of 2 to 3 percent. The dune sand was found to be saturated below elevation +9.5 MLLW in the northern reach. In the middle reach the dune sand was found to be saturated below +13.7 feet MLLW. The saturation line also was generally the dividing line between dense and very-dense sand. Blow counts per foot in the saturated dune sand were recorded to be as high as 91 in the northern reach, exceeded 91 in the middle reach, and were found to be 43 and probably greater near Wawona Street. The Colma Formation is, for the most part, very dense with blow counts exceeding 80 per foot being common. Clayey sand in the Colma Formation was found containing 17 to 18 percent fines. In the bottom of one boring, the clayey sand was found to contain 33 percent fines. Loose to medium dense lenses of silty to clayey sand are occasionally found in the Colma Formation, but none were encountered within the current study area.

Liquefaction. The October 1985 geotechnical report by Allstate provides an assessment of the liquefaction potential of the soils for its project. The assessment was made using the procedure of Seed, Tokimatsu, Harder, and Chung (1984). This procedure essentially correlates SPT blow counts with liquefaction behavior of saturated, clean and silty sands during historic earthquakes. The assessment concluded that large scale liquefaction is not likely, but that localized zones of moderate liquefaction potential exists. These zones are suspectable to liquefaction by a peak horizontal acceleration of 0.5g. Also, there may be localized areas of loose to medium-dense sand present between the widely spaced borings.

Seismically - Induced Settlements. Strong seismic ground motions could cause settlements due to compaction of soils above the groundwater level. Differential settlement can be expected to occur due to non-homogeneity of the soils and variations in their relative densities.

FOUNDATIONS FOR EROSION PROTECTION ALTERNATIVES

The foundation for the stone revetment and reinforced concrete seawall alternatives ranges from noncompacted in situ materials to compacted backfill and compacted in situ materials, respectively. The compaction requirements for the backfill and for a 2-foot-thick zone of compacted in situ material is taken

from the contract plans for the "Great Highway Seawall/Promenade, Spec. No. 3100W" by the Department of Public Works, City and County of San Francisco (1987). The compaction requirements for the in situ material and backfill beneath and behind the Seawall is 95 percent of maximum using standard compaction testing methods.

As the excavation for both the revetment and concrete seawall alternatives is immediately adjacent to roadways and parking lots, sheet piling or other means of temporary support will be necessary to support the Great Highway and its foundation. The sheet pile lengths and tip elevation were determined for a cantilevered sheet pile wall using one line of grouted, tieback anchors to reduce the bending moment.

Dewatering the foundation for both the revetment and concrete seawall alternatives will be necessary as groundwater was encountered at and above elevation +9.5 feet MLLW; the close proximity of the ocean exacerbates the occurrence of groundwater. It is anticipated that entire excavation sites will have to be enclosed by a sheet pile wall to greatly reduce groundwater inflow to the site while it is being dewatered. Additional subsurface investigations will be need to determine the in situ permeability, necessary for the design of a dewatering system.

The angle of internal friction used in calculating the passive and active earth pressures is a conservative 30°. A more detailed design analysis will probably layer the foundation soils in to two or more layers and assign appropriately higher values to the angle of internal friction to at least the bottom layer. Also, a more detailed design analysis may indicate that the use of multiple tieback lines may decrease the required pile lengths.

The foundation for a Taraval type sheetpile seawall considered for use in Reach III will consist of both loose, uncompacted in situ materials and dense to very dense Colma formation. The pile lengths and tip elevations are expected to correspond to those used in the original construction of the Taraval seawall completed in 1941.

<u>Revetment Alternative</u>. The revetment alternative would be constructed on a 2-foot horizontal to 1-foot vertical slope. A toe structure would be constructed from an elevation of +6 feet MLLW to -5 feet MLLW in order to protect the revetment against scour. The ends of the revetment will swing 90° to tie into the sheet pile wall along the Great Highway. After construction, the entire revetment would be buried and the existing dune field reconstructed (see Figure 1). While this

alternative could be used on all three reaches, it was essentially dropped from consideration due to the objections from the Golden Gate National Recreation Area (National Park Service) to rock revetment structures. In addition, dune retreat rates for Reaches I and II developed from numerical modeling, performed by the San Francisco Districts coastal engineer, of storm induced beach changes indicated that the Upper Great Highway would not be impacted until after fifty years beginning in 1995. The economic life of the revetment is taken as fifty years; therefore, no benefits would be realized. This alternative could, however, provide protection in Reach III.

Seawall Alternative. The foundation for the concrete seawall alternative requires the excavation of a 3.5-foot-thick layer of in situ material below the bottom of the concrete wall. The excavated layer would then backfilled with compacted sand. The compacted backfill would rest on a 2-foot-thick layer of compacted in situ material. The compaction requirements for both layers shall be 95 percent of maximum using standard compaction methods. (see Figures 2.)

Sheet piles for the toe cutoff wall and cross walls are required in the contract plans for the Great Highway Seawall/Promenade and therefore are included in this study. The purpose of the sheet-pile cutoff wall is to prevent beach scour from undermining the seawall's foundation. The cross walls would be placed on approximately 110-foot centers; their purpose is to prevent progressive failure of the seawall due to beach erosion and scour flanking the structure. Approximately 30 feet of sheet-pile wall would be required at each cutoff wall location. The ends of the seawall will be protected by a stone revetment that would swing 90° to tie into the sheet-pile wall along the roadways or parking lots.

The concrete seawall alternative was dropped from consideration for Reaches I and II due to the slow rates of dune retreat. Also, the National Park Service objected to a concrete seawall in Reach III because it is a hard structure and would not let the natural processes of nature control the beach morphology. The National Park Service owns the land in Reach III upon which the seawall would have to be constructed.

Taraval Sheet pile Seawall Alternative. The foundation for the sheet pile seawall is expected to be the Colma formation. The top of the Colma formation in Reach III is expected to be at or close to 0.0 foot MLLW and the pile tip elevations to be at approximately -14 feet MLLW. The top of the wall is to be a +13 feet MLLW, thus approximately one-half of the pile length would be in the Colma formation. The denseness of the Colma formation

would require jetting as well as driving. However, no subsurface investigations have been performed along the beach to verify foundation conditions. The sheet pile wall design is shown in Figure 3.

The designed excavation for the sheet pile seawall requires a 2 horizontal to 1 vertical backslope with a riprap protected toe. The backslope excavation would remove a large portion of the north, middle, and south parking lots (see Figures 4, 5, and 6). Although the parking lots would be reconstructed by placing fill over the excavation and seawall and graded to existing conditions, the Taraval type seawall would offer full protection to the sewer transport box but offer a lesser degree of protection to the parking lots. Coastal engineering design by the coastal engineer required the shown berm width between the seawall and backslope as well as the riprap toe protection to the backslope; their purpose is to counteract wave erosion due to overtopping during a severe storm event.

While the expected dune - parking lot retreat rate is fast enough to provide protection benefits, the National Park Service views this alternative as a hard structure and indicated that they would not support it.

Dune Nourishment Alternative

An alternative being considered in light of the extensive excavation necessary for a seawall is dune nourishment. The sand dunes fronting Ocean Beach are naturally nourished from the sandy beach by onshore winds. However, whether the dune face advances toward the shoreline or retreats from it is dependent on several variables among which are storm frequency and intensity, beach stability, and ultimately the availability of sufficient sand of appropriate size on the beach for nourishing the dunes.

The natural source of the sand for nourishing the dunes is the sand on Ocean Beach. The beach sand is found to exhibit wide variations in gradation. For example, a historical record consisting of 26 sand samples taken along Ocean Beach shows that the median grain-size (D_{50}) ranged from 0.27 mm to 1.57 mm with a median value of 0.38 mm and an average value of 0.47 mm (see Table 1). Of the 26 historical samples, data on eighteen of them were from winter beach conditions as reported by Echer (1980). One-half of Echer's data were from samples collected in December 1970 and the other half from samples collected in February 1979. The data on the remaining eight samples came from Plate 2 of Julius Schlocker (1974, U.S.G.S. Professional Paper 782). For a comparison, Table 1 shows the results of eight samples collected in September 1993 for the Corps of

Engineers by Bestor Engineers - Sea Surveyor, Inc. under the technical direction of coastal engineering. The September 1993 samples were taken along three survey range lines. The range lines are located at the following locations:

Range Line 14 is opposite Golden Gate Park; Range Line 11 is opposite the Upper Great Highway at the end of Noriega Street; and Range Line 5, opposite the southern end of San Francisco Zoo. The range lines run approximately normal to the shoreline and extend approximately one mile offshore from the Great Highway. The beach samples were taken from mid-berm to approximately 0.0 feet MLLW. The D_{50} grain-size of those samples ranges from 0.21 to 0.45 mm and averages 0.32 mm; the median value of the samples is 0.31 mm. The coarsest material was found in the active swash zone near 0.0 feet MLLW where the D_{50} grain-size ranged from 0.31 to 0.47 mm and the D_{84} grain-size ranged from 0.50 to 2.27 mm. The wide variation in gradation of the overall data of sand from Ocean Beach (Echer, Schlocker, and September 1993) reflects the influence of the coarser winter beach sand and may also be influenced by where on the beach the samples were taken.

Offshore of Ocean Beach, the sand becomes finer in an offshore direction as indicated by samples collected in September 1993. Four grab samples were taken on each of the three range lines at bottom depths of -10, -20, -30, and -40 feet MLLW. The D_{50} grain-size ranged from 0.15 to 0.21 mm and averaged 0.19 mm. Table 2 presents the composited data for the twelve samples.

TABLE 1

OCEAN BEACH: BEACH SAND

	Historical Samples	September 1993 Samples
D_{84} Average	0.94 mm	0.63 mm
D_{84} SD*	0.68 mm	0.56 mm
D_{84} Median	0.70 mm	0.40 mm
D_{84} Range	0.36 to 3.05 mm	0.30 to 2.00 mm
D_{50} Average	0.47 mm	0.32 mm
D_{50} SD	0.26 mm	0.07 mm
D_{50} Median	0.38 mm	0.31 mm
D_{50} Range	0.27 to 1.57 mm	0.21 to 0.45 mm

TABLE 1 Cont'd

OCEAN BEACH: BEACH SAND

	Historical Samples	September 1993 Samples
D_{16} Average	0.27 mm	0.21 mm
D_{16} SD	0.06 mm	0.05 mm
D_{16} Median	0.25 mm	0.21 mm
D_{16} Range	0.20 to 0.48 mm	0.12 to 0.27 mm
Average Percent Sand	No Data	100%
Range of Percent	No Data	99 to 100%

* SD is the sample standard deviation

TABLE 2

OCEAN BEACH: OFFSHORE SAND

	September 1993
D_{84} Average	0.26 mm
D_{84} SD*	0.06 mm
D_{84} Median	0.25 mm
D_{84} Range	0.18 to 0.40 mm
D_{50} Average	0.19 mm
D_{50} SD*	0.02 mm
D_{50} Median	0.19 mm
D_{50} Range	0.15 to 0.21 mm
D_{16} Average	0.14 mm
D_{16} SD*	0.01 mm
D_{16} Median	0.14 mm
D_{16} Range	0.12 to 0.16 mm

The sand dunes appear to be a poorly graded, moderately well sorted to well sorted sand. A review of data presented by Schlocker (1974) for 24 samples of dune sand taken at various localities in the San Francisco 7.5-minutes North Quadrangle show that the D_{50} grain-size ranged from 0.19 to 0.26 mm and averaged 0.22 mm; the median D_{50} value was also 0.22 mm (see Table 3). Schlocker's data compares favorably with the data from six samples of dune sand taken during the 1985 subsurface investigation by Allstate Geotechnical Services, and with seven grab samples taken along the three range lines in September 1993. Three samples of dune sand were taken along each of Range Lines 5 and 11, and only one sample taken on Range Line 14. Although the San Francisco District's Coastal Engineering group recommended using a D_{50} size of 0.30 to 0.50 mm for selection of a sand source, sand sources that have a D_{50} size between 0.25 mm and 0.64 mm are considered as potential construction materials in order to not be too restrictive in evaluating sand sources. A sand near the coarse limits of the D_{50} size will have a longer life in the dunes as it will have a higher threshold shear velocity resistance to wind erosion. It will also have a longer life on the beach as more energy will be required to transport coarser sand offshore.

The sand for the dune nourishment is anticipated to be brought to the site by either one of two ways depending upon the source. The sand may be hauled to the site by trucks and dumped on the existing dunes from the landside before final placement. Alternatively, the sand could be brought to the site by barge and off-loaded by a hydraulic pump. The sand would be deposited on the upper beach through a pipeline from the barge and then pushed up by bulldozers to form the sand dunes.

TABLE 3

DUNE SAND

	Schlocker (1974)	Allstate Geotechnical (1985)	September 1993
D_{84} Average	0.30 mm	0.35 mm	0.30 mm
D_{84} SD*	0.03 mm	--	0.07 mm
D_{84} Median	0.30 mm	--	0.28 mm
D_{84} Range	0.25 to 0.36 mm	0.23 to 0.36 mm	0.22 to 0.45 mm
D_{50} Average	0.22 mm	0.24 mm	0.21 mm
D_{50} SD*	0.02 mm	0.05 mm	0.03 mm
D_{50} Median	0.22 mm	0.22 mm	0.21 mm
D_{50} Range	0.19 to 0.26 mm	0.19 to 0.30 mm	0.15 to 0.25 mm

TABLE 3 Cont'd

DUNE SAND

	Schlocker (1974)	Allstate Geotechnical (1985)	September 1993
D_{16} Average	0.17 mm	0.18 mm	0.15 mm
D_{16} SD*	0.02 mm	--	0.03 mm
D_{16} Median	0.16 mm	--	0.15 mm
D_{16} Range	0.15 to 0.21 mm	0.14 to 0.19 mm	0.11 to 0.20 mm
Average % Sand	NA	98%	97%
Percent Range	NA	98-94%	85 to 100%
Average % > #4	NA	0%	1%
Percent Range	NA	0%	0-3%
Average < #200	NA	2%	2%
Percent Range	NA	2-4%	0-12%

The dune retreat rates and the frequency and quantities necessary for nourishment and re-nourishment are addressed in the Coastal Engineering Analysis Appendix.

Beach Nourishment Alternative. Another alternative to the extensive excavations required for seawall or revetment alternatives is beach nourishment. This alternative has been proposed by the local sponsor, the City of San Francisco. This alternative is further addressed in the Coastal Engineering Analysis Appendix.

CONSTRUCTION MATERIALS

Revetment Alternative. The stone for the revetment alternative would be required to meet the following weight size requirements as supplied by the coastal engineering section. The average armor stone weight was determined using the Hudson formula as given in EM 1110-2-1614 (30 April 1985 with change 1, 30 July 1986), and in the Shore Protection Manual (1984). A bulk saturated surface-dry specific gravity of 2.65 was used in the calculations.

a. Armor (A) Stone: minimum stone size 2.3 tons; maximum stone size 4.0 tons with at least 50 percent of the stones heavier than 3.1 tons.

b. First Underlayer Stone: minimum size 435 pounds; maximum size of 810 pounds with at least 50 percent of the stones heavier than 622 pounds.

c. Bedding Layer: minimum size 15 pounds; maximum size 47 pounds with at least 50 percent larger than 31 pounds.

Armor stone that meets the above gradation may be obtained from the following quarries. These quarries are capable of producing stones of acceptable quality.

a. San Rafael Quarry near San Rafael, Marin Co., California.

b. Lake Herman Quarry near Vallejo, Solano Co., California.

c. Stonewall Canyon Quarry near Soledad, Monterey Co., California.

d. Pieta Quarry near Hopland, Mendocino Co., California.

e. Circle "A" Ranch Quarry near Hopland, Mendocino Co., California.

Underlayer material may be obtained from the above quarries as well as the Napa Quarry in Napa, Napa Co., California.

Bedding material is much more plentiful. It can be obtained from the following sources.

a. Brisbane Quarry in Brisbane, San Francisco Co., California.

b. San Rafael Quarry near San Rafael, Marin Co., California.

c. Kaiser's Clayton Quarry near Clayton, Contra Costa Co., California.

d. Lake Herman Quarry near Vallejo, Solano Co., California.

e. Napa Quarry near Napa, Napa Co., California.

Seawall Alternative. Sand and gravel for concrete aggregate can be obtained from various sand and gravel companies working in Livermore Valley and in the Niles District along Alameda Creek. Cement for the reinforced concrete may be obtained from either Kaiser-Permanent Co. near Cupertino, Santa Clara County, California or from the Calaveras Cement Co. near San Andreas, Calaveras County, California.

Dune Nourishment Alternative. A preliminary investigation of potential sand sources was conducted during the summer of 1993 (Sand, 1994). Several potential sources were contacted by letter and those that responded were subsequently contacted by telephone. Arrangements were then made to collect small grab samples for laboratory mechanical analysis of the occurring sand. In later summer 1993 sand samples were collected from the follow sources: Mega Sand, Inc. of Antioch, California; Tidewater Sand and Gravel, Inc. of Oakland, California; Kaiser Sand and Gravel Co. of Pleasanton, California; and R.M.C. Lonestar Co. of Pleasanton, California. The sand source(s) available from each of these firms will be discussed in more detail in the follow paragraphs.

Mega Sand, Inc. is located in Antioch, California, and has sand that has been dredged from the Sacramento River and stockpiled on Decker Island in the Sacramento River downstream of Rio Vista, California, and on land adjacent to the River. Mega Sand currently has a permit to mine sand from the Sacramento River Deep Water Ship Channel from river mile 6.5, near Decker Island, to river mile 14.2, near Grand Island at Rio Vista, only within the border of Solano County. Its permit allows for the dredging of up to 880,000 cubic yards per month for four months per year. Mega Sand has not only expressed interest in supplying sand for the Ocean Beach project but also expressed interest in bidding the job as a contractor for placement of the sand. Mega Sand has a 4,000 ton scow barge equipped with a 20-inch Thomas hydraulic pump for off-loading. The sand would come from the stockpiles on Decker Island and adjacent land located approximately 67 barge miles from the project site. In the fall of 1994, the estimated cost per cubic yard of sand at Decker Island was $8.90 per cubic yard undelivered.

Four grab samples were taken from different areas of stockpiled material and sent to the South Pacific Division Laboratory for mechanical analyses (sieve analyses). The results of the four test were combined with the results of a test performed by Klienfelder Laboratory, May 1992, on Decker Island sand. The results are as follows:

	D_{16}–	D_{50}–	D_{84}–	Percent Sand	Percent > #4 Sieve	Percent < #200 Sieve
Average	0.21 mm	0.31 mm	0.47 mm	99.4%	0.2%	0.4%
Median	0.20 mm	0.32 mm	0.48 mm	--	--	--
Range	0.19 mm to 0.25 mm	0.27 mm to 0.32 mm	0.34 mm to 0.58 mm	98% to 100%	0% to 1%	0% to 1%

The sand is poorly graded, moderately well sorted to well sorted with a relatively uniform grain-size. The inclusive graphic phi-standard deviation (Masch and Denny, 1966) ranges from 0.37 to 0.70 phi with a median value of 0.68 phi. The inclusive graphic phi-skewness ranges from -0.50 to 0.24 with a median value of 0.00.

Tidewater Sand and Gravel, Inc. mines sand from the San Francisco Bay and from Suisun Bay. A grab sample of sand was collected from each of two stockpiles in Tidewater's Oakland storage yard. The samples were from the Presidio Shoal area and the Point Knox Shoal-Angel Island area. The Presidio Shoal is located offshore of the San Francisco Presidio, east of the Golden Gate Bridge. Point Knox Shoal is located at the western end of Raccoon Strait and southwest of Angel Island. The sample data from the Presidio Shoal grab sample was added to data from three different samples provided by Tidewater. The sand is a poorly graded, well sorted fine sand with a nearly uniform grain-size. The results of the mechanical analyses are as follows:

	D_{16}	D_{50}	D_{84}	Percent Sand	Percent > #4 Sieve	Percent < #200 Sieve
Average	0.20 mm	0.27 mm	0.36 mm	99%	0%	1%
Range	0.19 mm to 0.22 mm	0.24 mm to 0.30 mm	0.35 mm to 0.40 mm	98% to 100%	0% to 1%	0% to 1%

The sample collected in late summer 1993 has an inclusive graphic phi-standard deviation of 0.44 phi, and an inclusive graphic phi-skewness of 0.09 indicating a well sorted sand with a nearly symmetrical distribution about the D_{50} size.

A sample of sand was also collected from the material mined from the Point Knox Shoal-Angel Island area. This sample is much coarser and more widely graded than the Presidio Shoal sand. Tidewater had previously furnished the results of a gradation analysis on a sample from the same area. That material also has a wide gradation and is significantly coarser than Presidio Shoal sand. The sand is poorly graded and poorly sorted. The results of the two analyses are as follows:

	D_{16}	D_{50}	D_{85}	Coefficient of Uniformity
COE August 1993	0.27 mm	0.65 mm	1.60 mm	3.73
Tidewater, May 1991	0.30 mm	0.84 mm	2.51 mm	5.26

The sand from the COE sample and Tidewater sample have an inclusive graphic phi-standard deviation of 1.16 phi and 1.43 phi respectively. Both samples were nearly symmetrically distributed about the D_{50} grain-size. Due to the wide gradation and the coarseness of the plus D_{50} size, this material is less compatible with dune sand at Ocean Beach than is the sand from Presidio Shoal.

Tidewater sand and Gravel also mines sand in the Suisun Bay area and stores the material in its yard at Martinez, California. The material is called Martinez fill sand. This material was not sampled. However, Tidewater has provided the results of two separate gradation analyses. The results from the gradation analyses indicate that the Martinez fill sand is very similar to the material from Presidio Shoal. The D_{50} of the two samples range from 0.24 to 0.27 mm. The gradation curves show the sand to be poorly graded, well sorted, and nearly symmetrical about the D_{50} grain-size.

Tidewater is currently permitted to mine 600,000 cubic yards per year of sand from Presidio Shoal and 300,000 cubic yards per year from Point Knox Shoal-Angel Island area. Tidewater currently does not mine up to its permitted production. Its main yard is in Oakland, but it has a smaller yard located in the Islais Creek basin on the eastern side of the San Francisco Peninsula. There is a possibility that sand could be shipped directly to barge from the mining area to offshore of Ocean Beach. However, do to obligations to its regular customers and other economic factors, Tidewater was not ready to quote a price per cubic yard for furnishing sand to barges at the mining site. Tidewater did furnish price per cubic yard of sand undelivered from its Oakland yard of approximately $8.00 (fall 1994).

Kaiser and R.M.C. Lonestar both have an open pit mining operation that mines sand from the weekly consolidated Santa Magarita Sandstone of late Miocene to early Pliocene marine sand. The sandstone is easily broken down into its individual sand grains. The mining operations are located in Scotts Valley near Felton in Santa Cruz County, California. The haul distance is approximately 82 miles to Ocean Beach. Both Kaiser and R.M.C. Lonestar produce two sand products called Felton No. 1 and No. 2. The Felton No. 1 sand from both companies are very much alike while there is some difference between their Felton No. 2 sands. The results of the grain-size analyses of grab samples from the two companies are as follows:

	D_{16}	D_{50}	D_{84}	Percent Sand	Percent > #4 Sieve	Percent < #200 Sieve
Felton No. 1	0.20 mm	0.40 mm	0.68 mm	97%	0%	3%
Lonestar No. 2	0.23 mm	0.72 mm	1.02 mm	98%	0%	1%
Kaiser No. 2	0.28 mm	0.56 mm	1.00 mm	99%	0%	0%

Note the similarity between Kaiser No. 2 and Lonestar No. 2 except for the D_{50} grain-size for which Lonestar is noticeably coarser. The Felton No. 1 sand has an inclusive graphic phi-standard deviation of 0.92 phi as compared to 0.90 phi and 0.94 phi for Lonestar No. 2 and Kaiser No. 2 respectively. The inclusive graphic phi-skewness for Felton No. 1 is 0.16 whereas Lonestar No. 2 and Kaiser No. 2 are 0.53 and 0.23 respectively, indicating that Felton No. 1 is more evenly distributed about the D_{50} grain-size than either Lonestar No. 2 or Kaiser No. 2. Both Felton No. 1 and Lonestar and Kaiser No. 2 are poorly graded, moderately well sorted and somewhat skewed towards the fine side; Lonestar No. 2 the most skewed. By its coarseness, sand from the Felton mining operations would add stability to the dunes against wind erosion and would be less susceptible to being removed from the beach.

Kaiser Sand and Gravel indicated that it would be willing to supply the sand for the Ocean Beach project if it proves to be cost effective to haul from Felton. The cost of sand per cubic yard undelivered from Kaiser's pit has been estimated at approximately $10.50 (fall 1994). The cost of sand from R.M.C. Lonestar's pit is expected to be competitive with Kaiser although Lonestar is uncertain it wants to commit to being a potential supplier.

Monterey Bay Concrete and Supply, Inc. (formerly known as Monterey Sand Company, Inc.) is located in Sand City at the southern end of Monterey, California; and it is willing to supply Monterey dune sand for the Ocean Beach project. Monterey dune sand is a moderately well to well sorted, poorly graded sand slightly skewed to the coarse side. It is slightly coarser than Ocean Beach dune sand, but is expected to have similar grain-shape characteristics. Information from Monterey Bay Concrete and Supply, R.M.C. Lonestar, and other readily available sources indicates that Monterey dune sand has the following grain-size ranges.

D_{16}	0.18 mm to 0.40 mm
D_{50}	0.27 mm to 0.54 mm
D_{84}	0.36 mm to 0.75 mm
Percent Sand	92-100%
Percent > #4 Sieve	0%
Percent < #200 Sieve	0-8%

A gradation range of dune sand received from Monterey Bay Concrete and supply dated 18 July 1994 had a D_{16} range of 0.20 to 0.24 mm, a D_{50} ranges of 0.28 to 0.34 mm, and a D_{84} range of 0.36 to 0.46 mm. The range of percent of sand is 97 to 100% with 0 to 3% passing the No. 200 sieve.

Due to its distance from Ocean Beach, Monterey dune sand is not considered to be competitive for truck hauling. Also, there is no known location in Monterey Bay through which barges could be loaded from a land-based mining operation. The last time dune sand was barged from Monterey Bay was apparently during the 1950's; the sand was loaded on to barges at the Monterey wharf. It is doubtful that the City of Monterey would permit the heavy truck traffic necessary to load sand barges. It is estimated that approximately 90 truck loads of sand at 25 tons per truck load would be required per barge load. Also, the existing facilities at Moss Landing, located approximately 15 miles northeast of Monterey, are not amenable to on-loading barges with sand. Thus, Monterey dune sand has not been costed out at this time as a source for the Ocean Beach project.

In Summary the most viable sources of sand as reflected by cost will be the Presidio Shoal for truck hauling and Mega Sand's Decker Island for barge hauling, although barge hauling from Presidio Shoal may be a possibility. The estimated cost of approximately $18 per cubic yard (fall 1994) for Mega Sand to obtain, deliver, and construct sand dunes at Ocean Beach must be tempered. Mega Sand's estimated cost must be tempered with the knowledge that Mega Sand expects to have ownership of and ready access to all the major pieces of equipment necessary to accomplish the work, including a single-point mooring buoy for direct pumpout, by the time the project is ready to construct. Mega Sand has indicated that they are in the process of acquiring the equipment and would be expected to have low mobilization costs. For a comparison, both Great Lakes Dredging Company and Dutra Construction Company were queried for an estimate of cost for barge pumpout from offshore. Great Lakes Dredging has had much experience with hydraulic pumping of sand for beach nourishment. Dutra Construction has had experience working offshore of Ocean Beach; it was involved with the construction of San Francisco's Southwest Ocean Outfall Project (SWOOP). Both companies responded with

cautious, conservative, ball-park estimates. In fact, Dutra Construction was very reluctant to give any cost due to the hazardous working conditions of the offshore wave climate. Their estimates did not include cost of sand or delivery cost as they did not have sufficient information as to a sand source. However, during early fall 1994 both companies estimated that placement cost would range from $6 to $10 per cubic yard in addition to relatively higher mobilization cost. Great Lakes estimated its mobilization cost at $500,000 while Dutra Construction estimated it mobilization cost at $50,000 per each piece of equipment they would use. It would seem that Mega Sand's estimated cost of approximately $18 per yard placed may be overly optimistic.

The sand from Decker Island is slightly coarser than the Ocean Beach dune sand while the sand from Presidio Shoal is very similar in gradation to the dune sand. For substantially increased stability against wind erosion and increased retention on the beach, the sand from the Felton pit would be better suited.

Beach Nourishment Alternative. The designed beach nourishment alternative would require hydraulically placed sand fill to elevation +15 feet MLLW with a 100 horizontal to 2 vertical oceanward slope and have closure with the seafloor at -35 feet MLLW. The beach nourishment alternative is described in greater detail in the Coastal Engineering Analysis Appendix. The sand for beach nourishment may have to be obtained from both in-bay and out-of-bay sources in order to provide the estimated quantities for initial placement and periodic re-nourishment

Potential sources of sand materials would be the same as for dune nourishment as well as the San Francisco Bar located outside of the Golden Gate. However, the results of the beach nourishment alternative study indicates that due to the large quantities of sand necessary to maintain sufficient protective beach width, the cost of the beach nourishment alternative would exceed the expected benefits. Therefore, this alternative is not being pursued.

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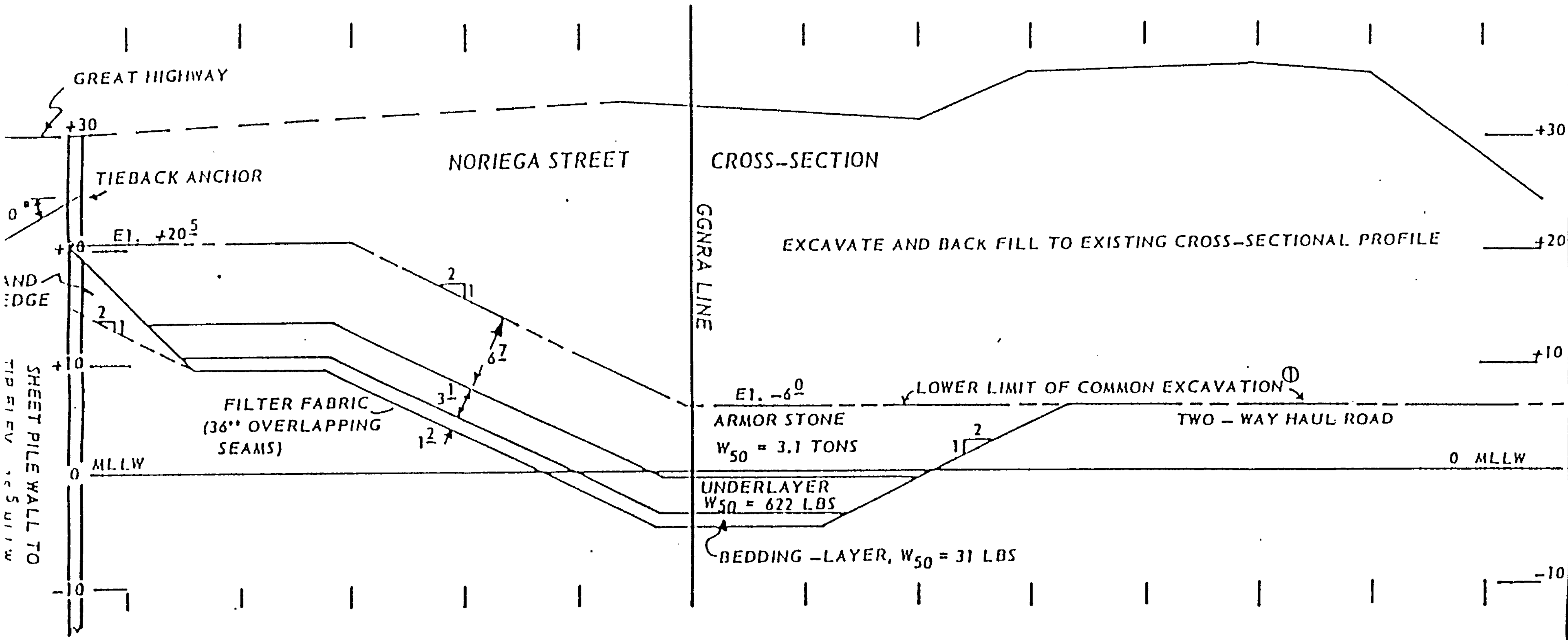


TYPICAL REVETMENT SECTION

GENERAL NOTES:

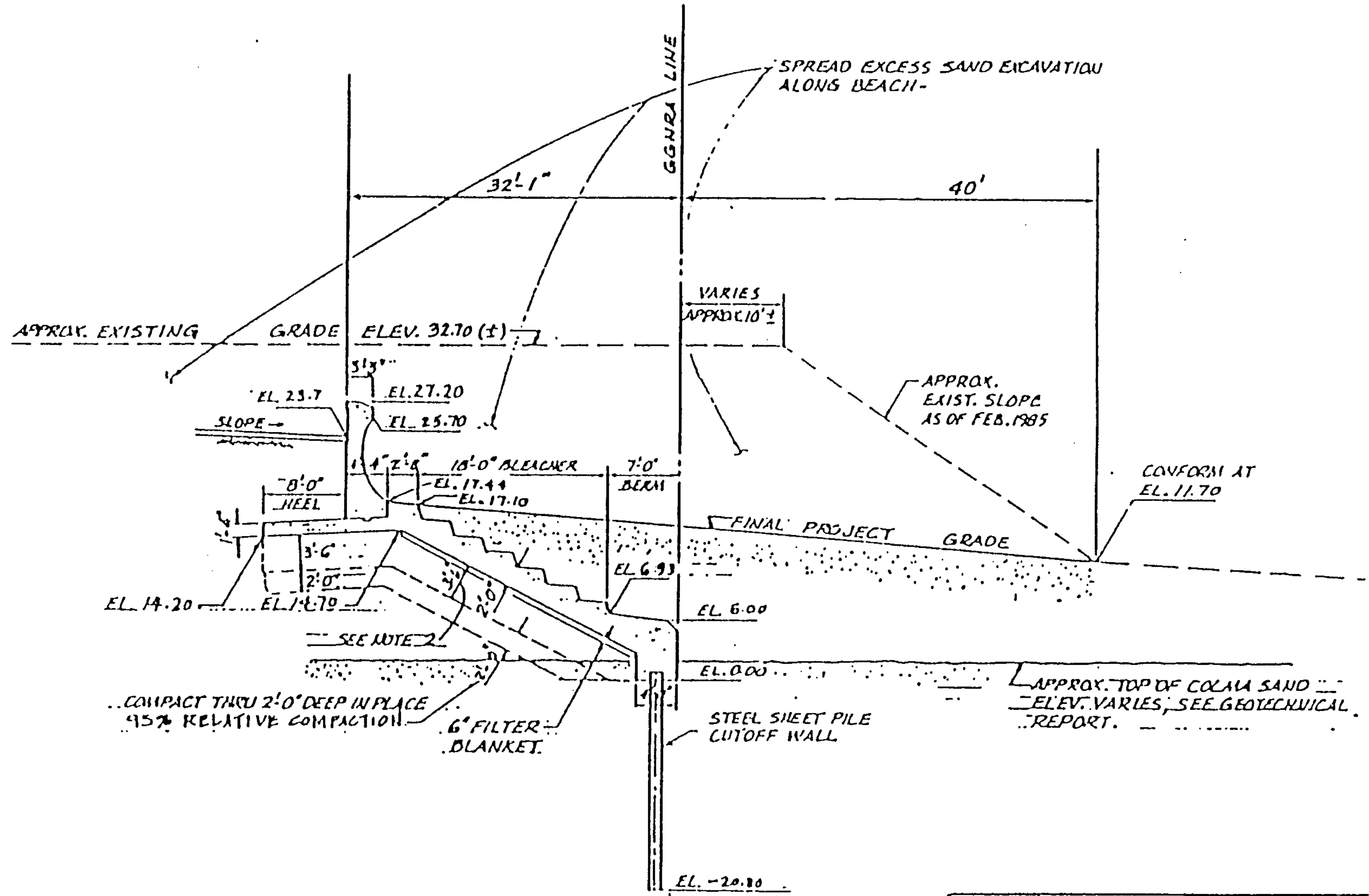
1. EXCAVATION ABOVE THE LOWER LIMIT LINE IS COMMON TO BOTH SEAWALL AND REVETMENT ALTERNATIVES.
2. CROSS-SECTION PROFILE SURVEYED 31 JANUARY 1985. BY THE CITY OF SAN FRANCISCO.
3. DATUM IS MEAN LOWER LOW WATER (MLLW).
4. MEASUREMENTS ARE IN FEET AND TENTHS OF FOOT.

SAN FRANCISCO COUNTY CALIFORNIA
OCEAN BEACH
STORM DAMAGE REDUCTION
RECONNAISSANCE STUDY
REVETMENT ALTERNATIVE

SECTION

U.S. ARMY ENGINEER DIST. SAN FRANCISCO
DRAWN
TRACED
TO ACCOMPANY REPORT
FILE NO

Figure 1



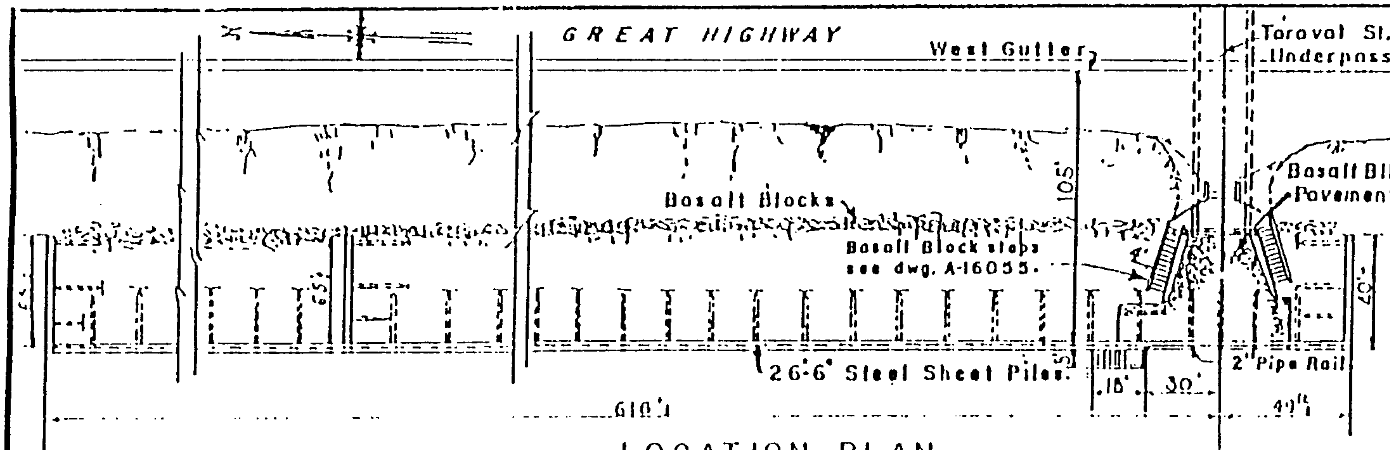
REACHES I and II

TYPICAL CROSS SECTION

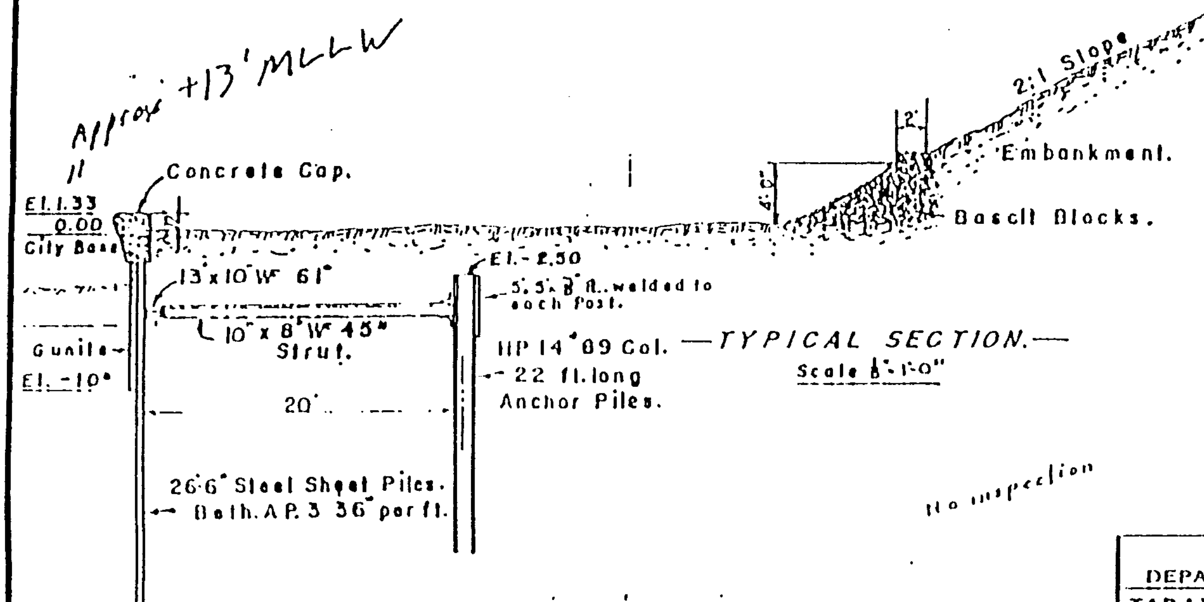
SAN FRANCISCO COUNTY CALIFORNIA
OCEAN BEACH
STORM DAMAGE REDUCTION
RECONNAISSANCE STUDY
SEAWALL ALTERNATIVE
SECTION

U.S. ARMY ENGINEER DIST. SAN FRANCISCO C OF
DRAWN FILE NO

Figure 2



—LOCATION PLAN—
SCALE 1"=50'



—TYPICAL SECTION.—
Scale 1/8"=1'-0"

No inspection

INSPECTION SCHEDULE.

Inspection Date.	Inspector	Remarks.
Dec. 17-41	J. Kazon	See File 5-95 Book 5
Oct. 2-42	A.J. Dullke	" " " " 6
July 2-43	F.J. Lewis	
Apl. 25-44	J. Kazan	
May 21-45	T. Breslin	
Jan. 22-46	T. Breslin	
Mar. 19-48	F. Lewis	
Mar. 7-51	M Dmitrieff	
Oct. 24-52	M Dmitrieff	
June 19-53	M Dmitrieff	
Mar. 24-54	M Dmitrieff	
Mar. 10-55	M Dmitrieff	
Nov. 5-56	" "	
June 11-57	" "	
Apl. 28-58	" "	
Mar. 24-59	" "	
Sept. 30-60	" "	
May 31-61	" "	
May 22-62	" "	
Apl. 3-63	" "	

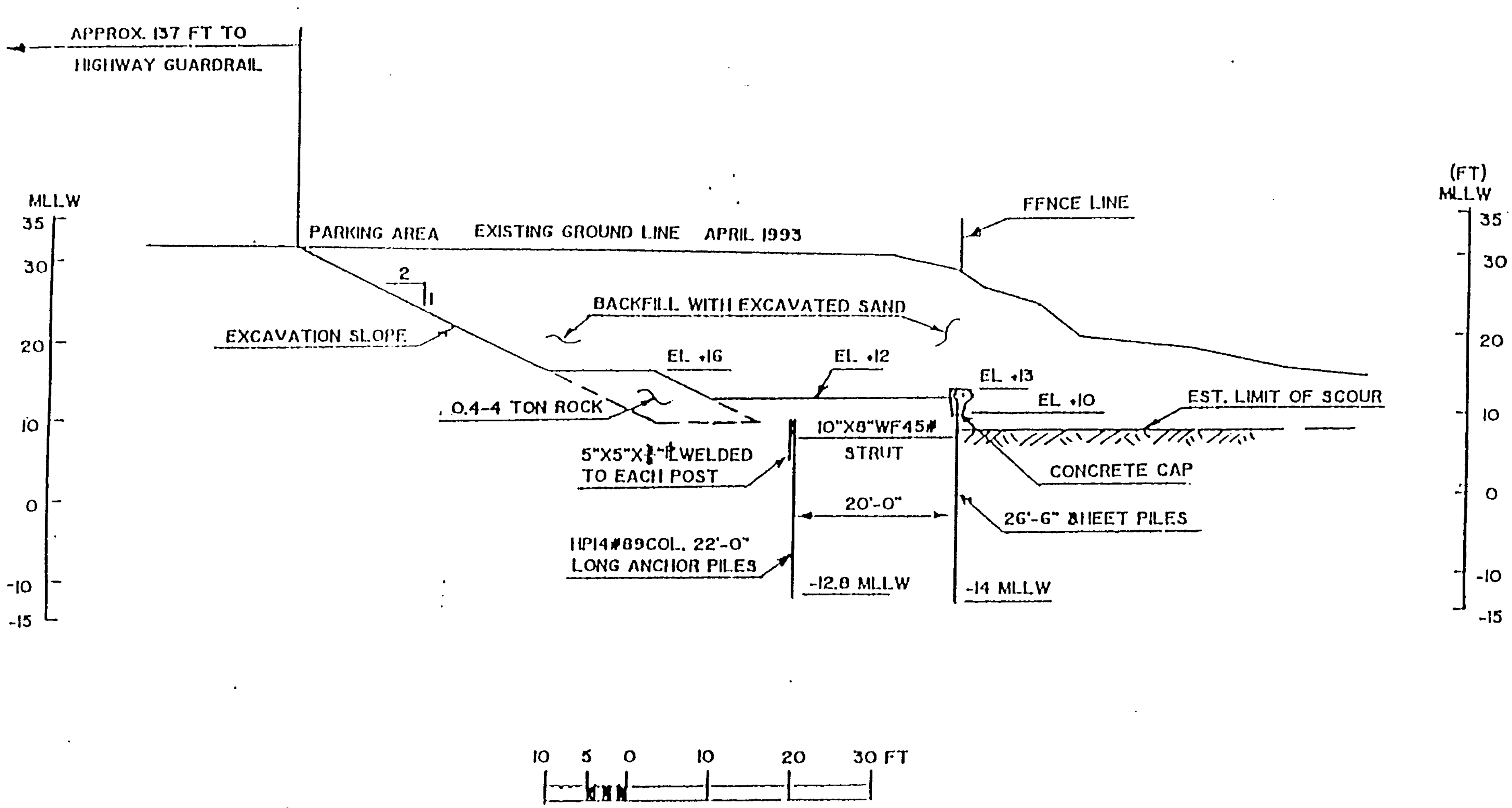
REFERENCE DRAWINGS	
Plan and Details	A-15184
"	A-15190
"	A-15252
Basalt Block Steps	A-16055

CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS - BUREAU OF ENGINEERING
TARAVAL ST. BULKHEAD AT GREAT HIGHWAY.
INSPECTION SCHEDULE.

APPROVED: John J. Casey. CIVIL ENGINEER CITY ENGINEER
DRAWN BY AJD. TRACED BY CHECKED BY V.B.C
DATE MAY 1941
FILE L-14728
MAP 5

Figure 3

05

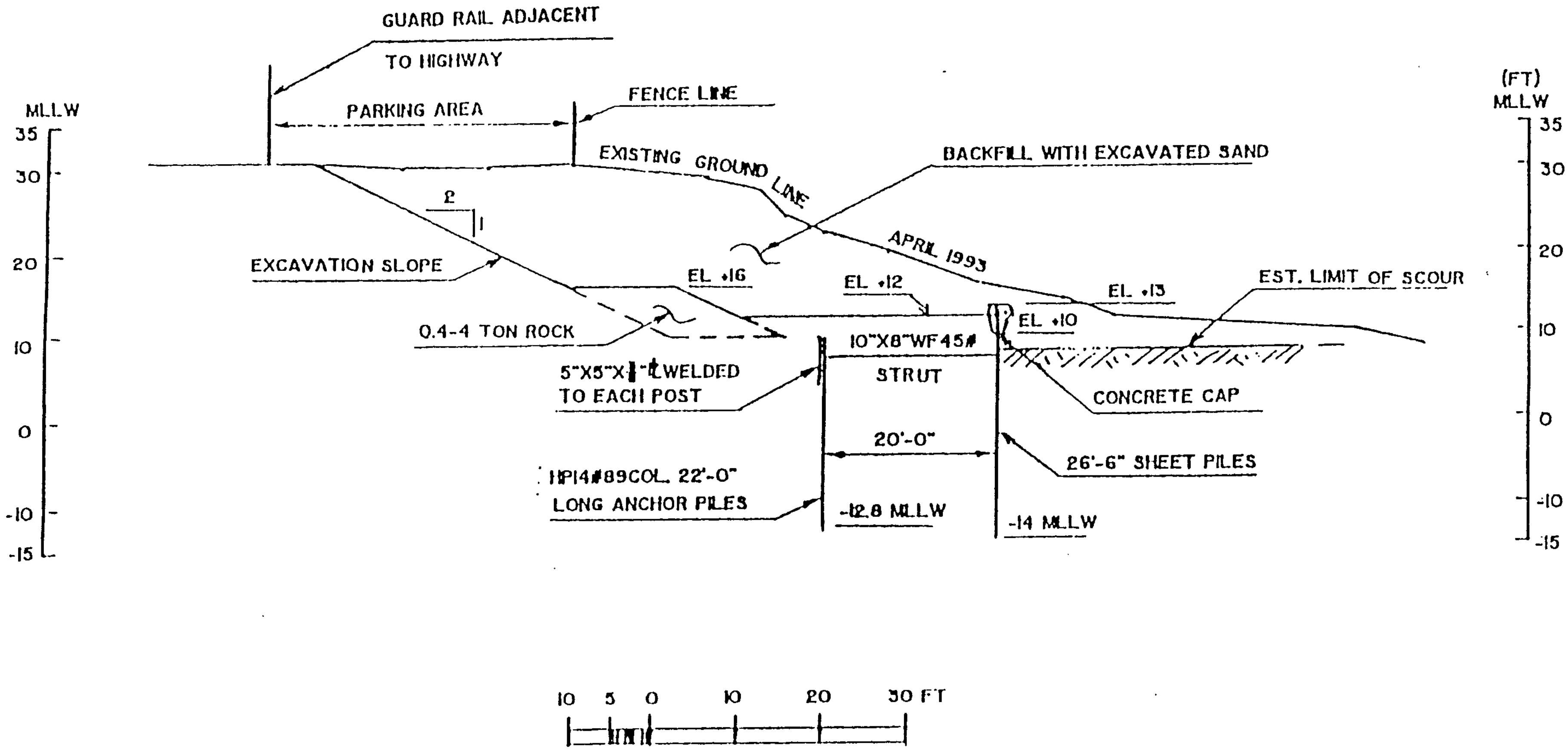


REACH III

NORTHERN PARKING LOT

TARAVAL TYPE WALL CROSS SECTION

Figure 4

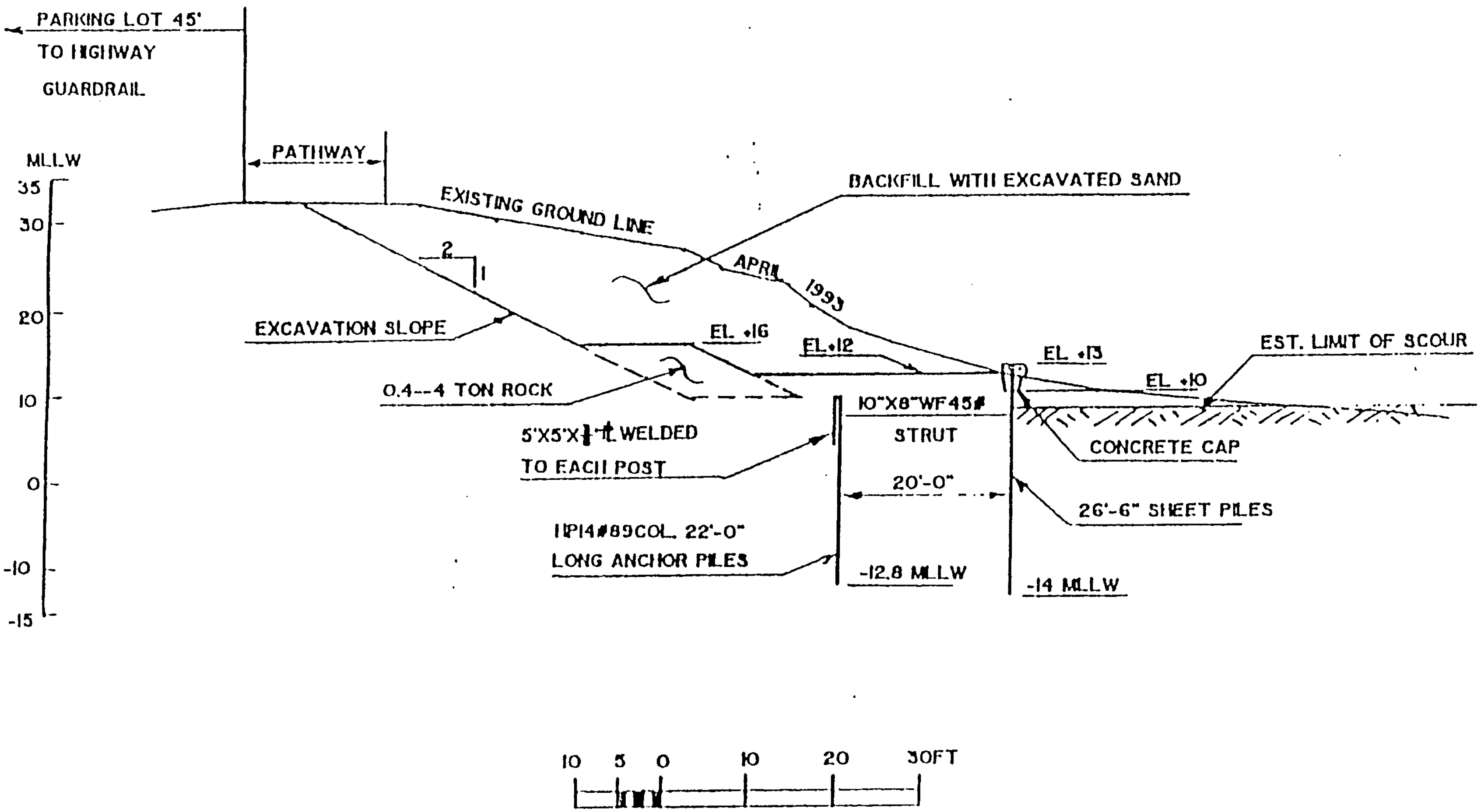


REACH III

MIDDLE PARKING LOT

TARAVAL TYPE WALL CROSS SECTION

Figure 5



REACH III
SOUTHERN PARKING LOT

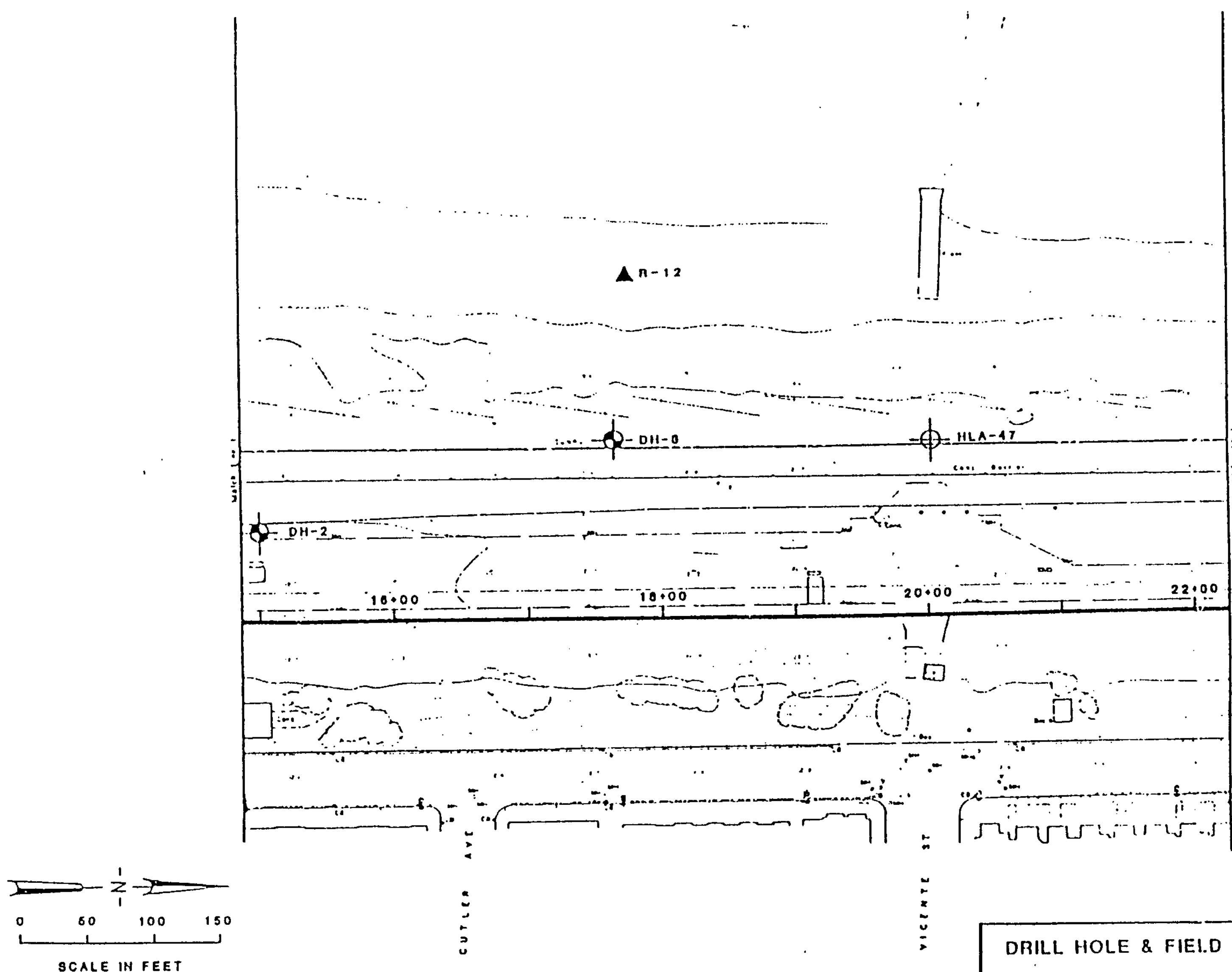
TARAVAL TYPE WALL CROSS SECTION

Figure 6

Attachment 1

Geotechnical Physical Data From

"Geotechnical Investigation, New Great Highway Seawall"
by Allstate Geotechnical Services in association with
woodward-Clyde Consultants, October 1985:
Prepared for San Francisco Clean Water Program
City and County of San Francisco

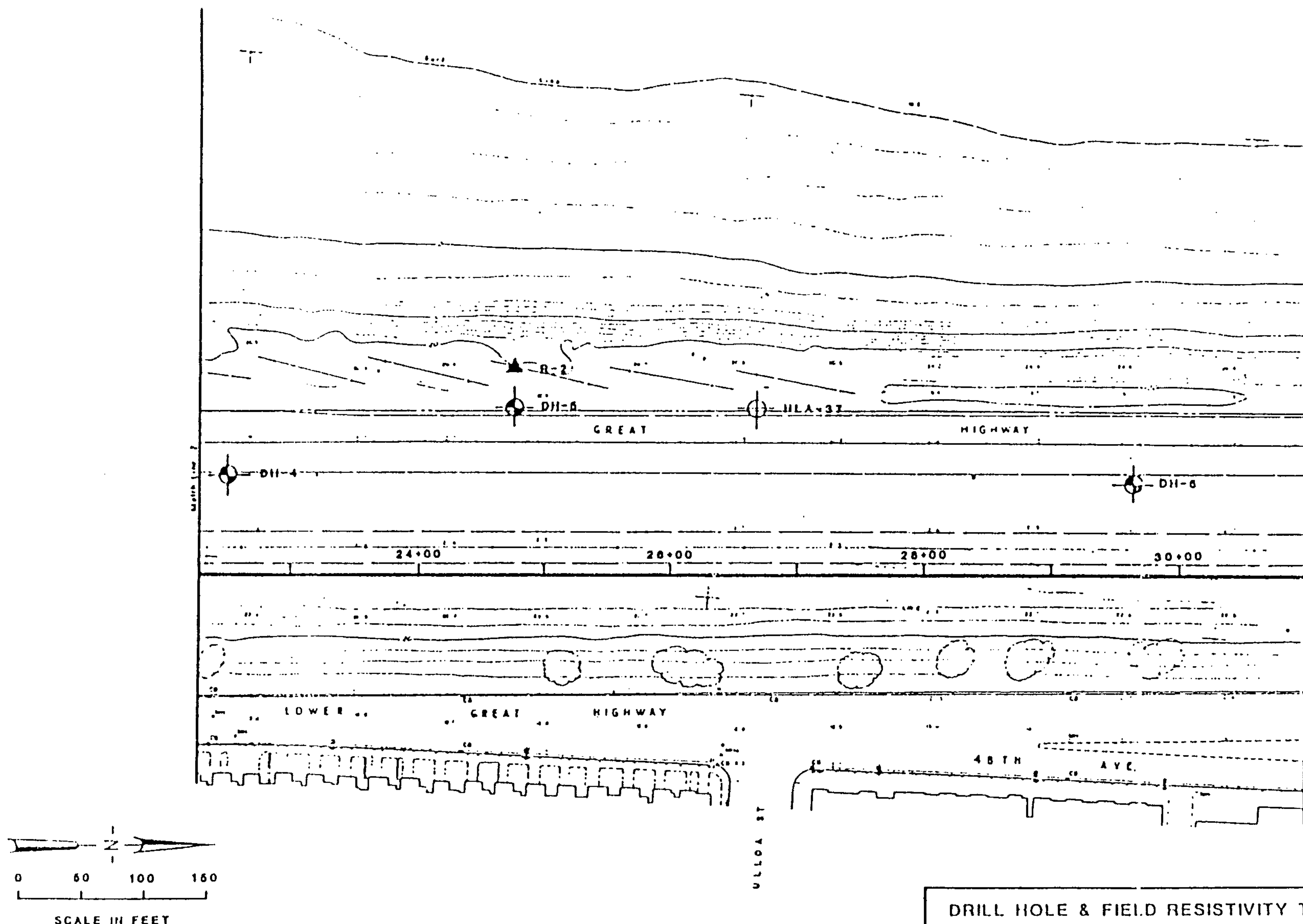


ADAPTED FROM SAN FRANCISCO CLEAN WATER PROGRAM
TOPOGRAPHIC DRAWING NO. 2 , JOB NO. 1167W

DRILL HOLE & FIELD RESISTIVITY TEST LOCATION MAP

NEW GREAT HIGHWAY SEAWALL

JOB NO. SF841104	DATE: 6/1985	PLATE - 1.2

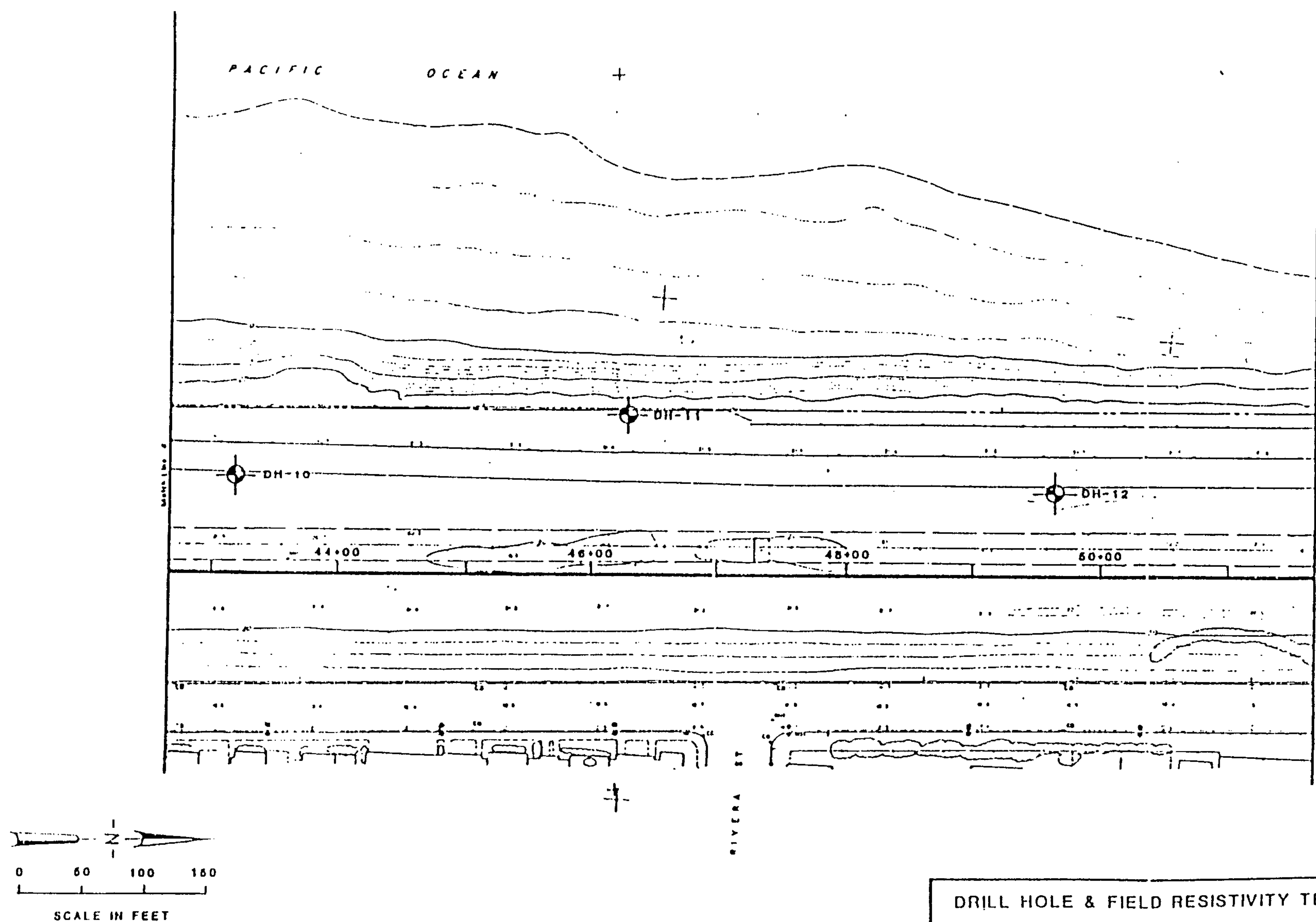


ADAPTED FROM SAN FRANCISCO CLEAN WATER PROGRAM
TOPOGRAPHIC DRAWING NO. 5, JOB NO. 1167W

DRILL HOLE & FIELD RESISTIVITY TEST LOCATION MAP

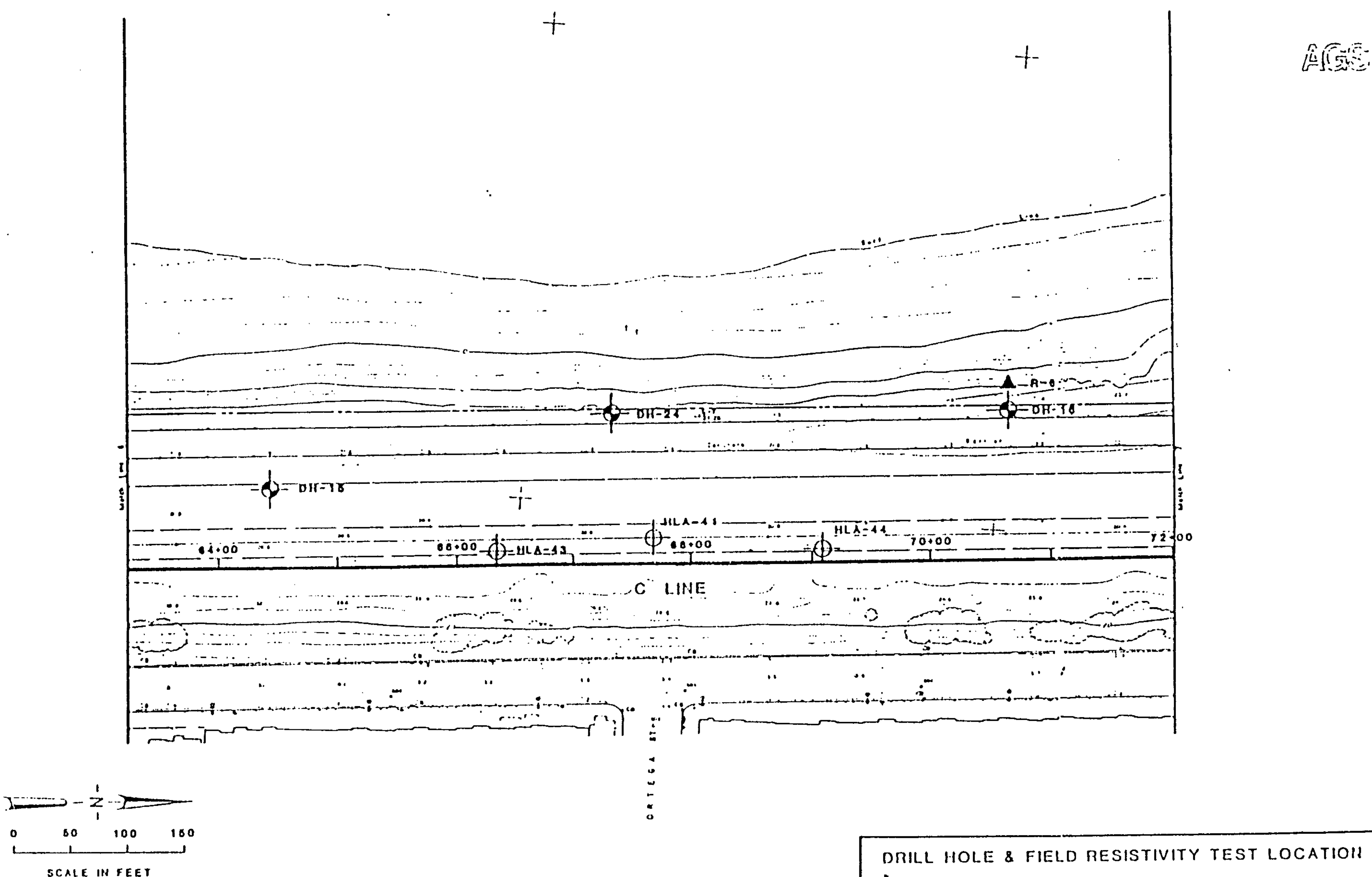
NEW GREAT HIGHWAY SEAWALL

JOB NO. SF841104	DATE: 6/1985	PLATE - 1.3



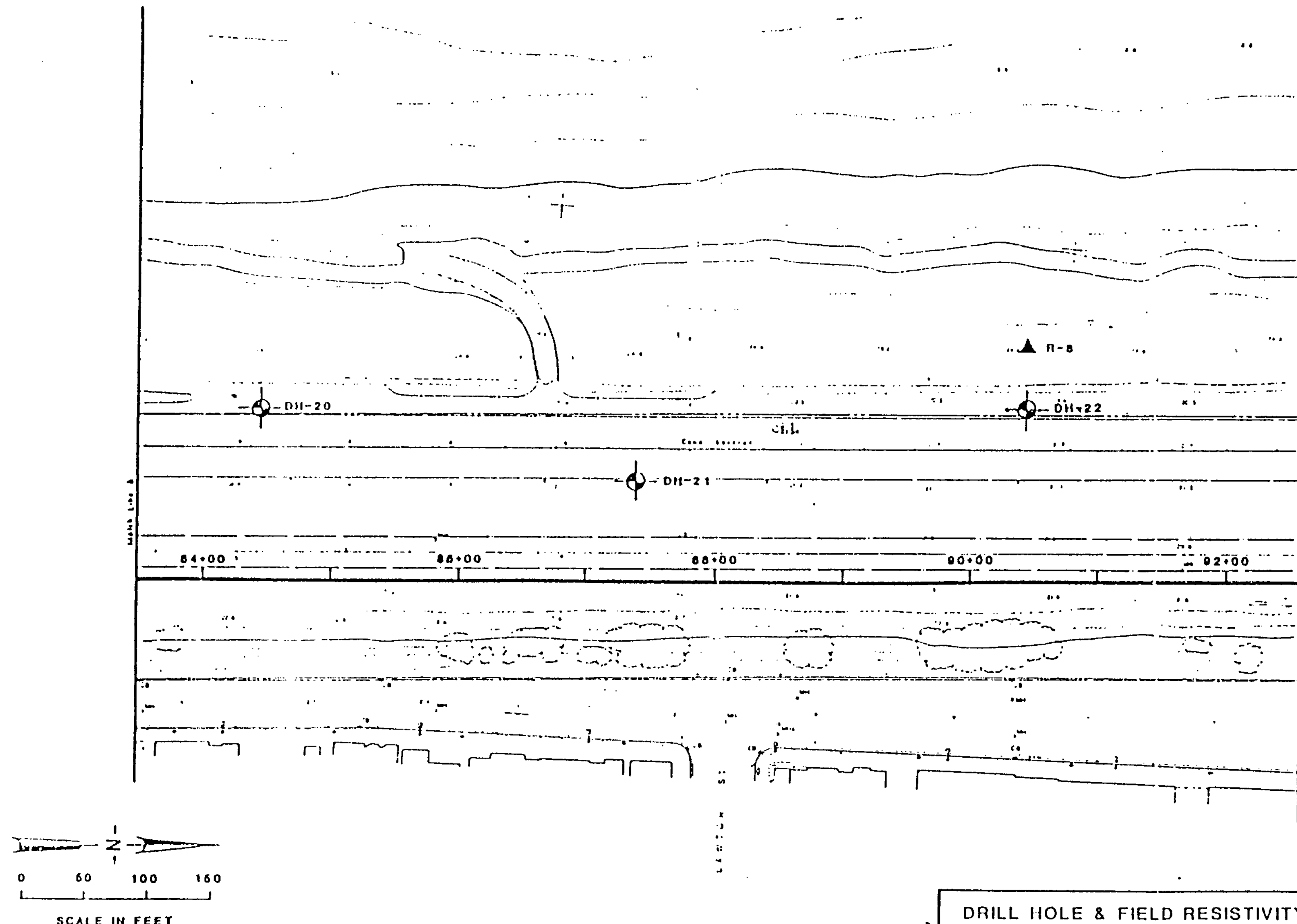
ADAPTED FROM SAN FRANCISCO CLEAN WATER PROGRAM
TOPOGRAPHIC DRAWING NO. 6, JOB NO. 1167W

DRILL HOLE & FIELD RESISTIVITY TEST LOCATION MAP		
NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841104	DATE: 6/1986	PLATE – 1.5



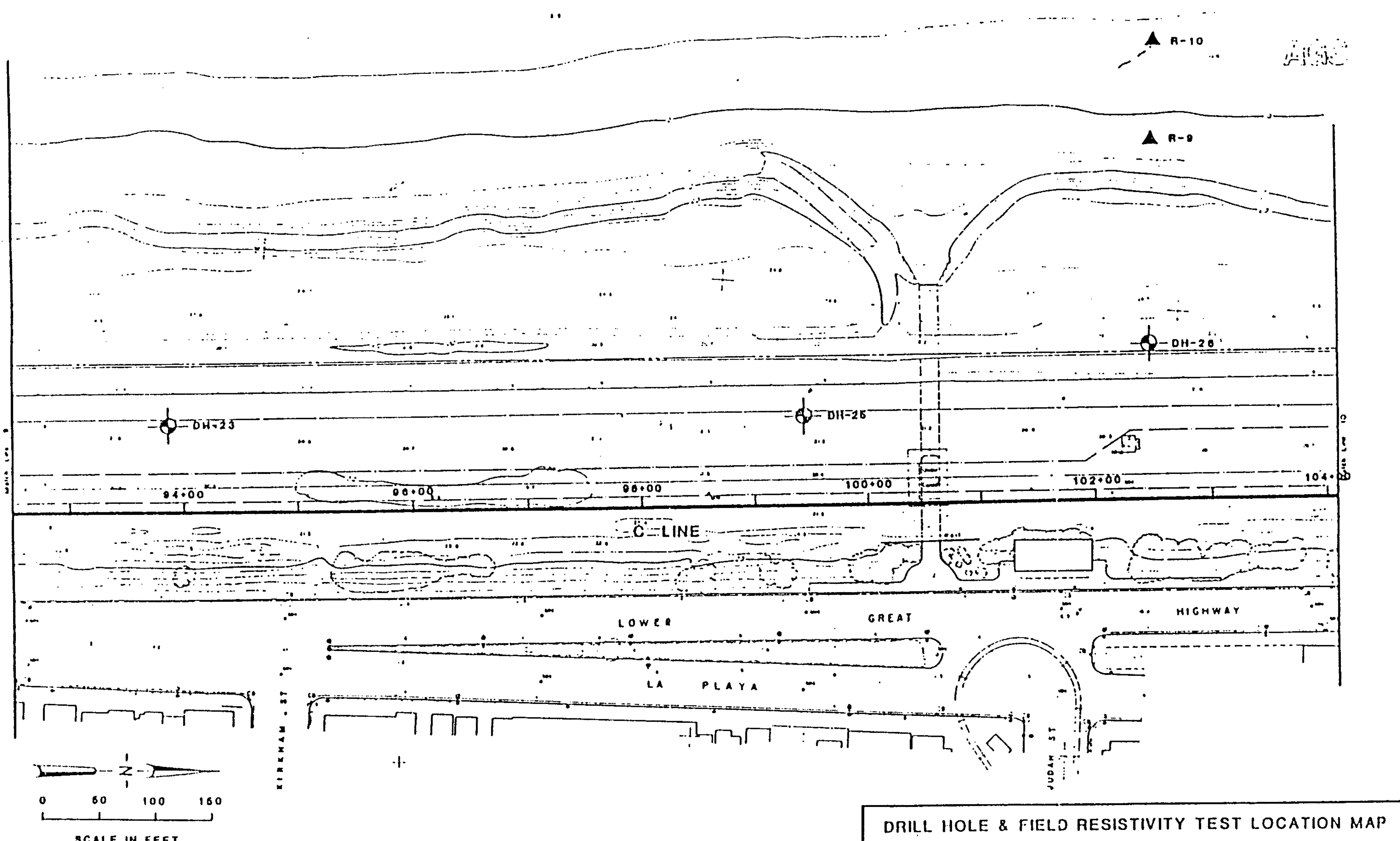
ADAPTED FROM SAN FRANCISCO CLEAN WATER PROGRAM
TOPOGRAPHIC DRAWING NO. 7, JOB NO. 1167W

DRILL HOLE & FIELD RESISTIVITY TEST LOCATION MAP		
NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841104	DATE: 6/1986	PLATE - 1.7



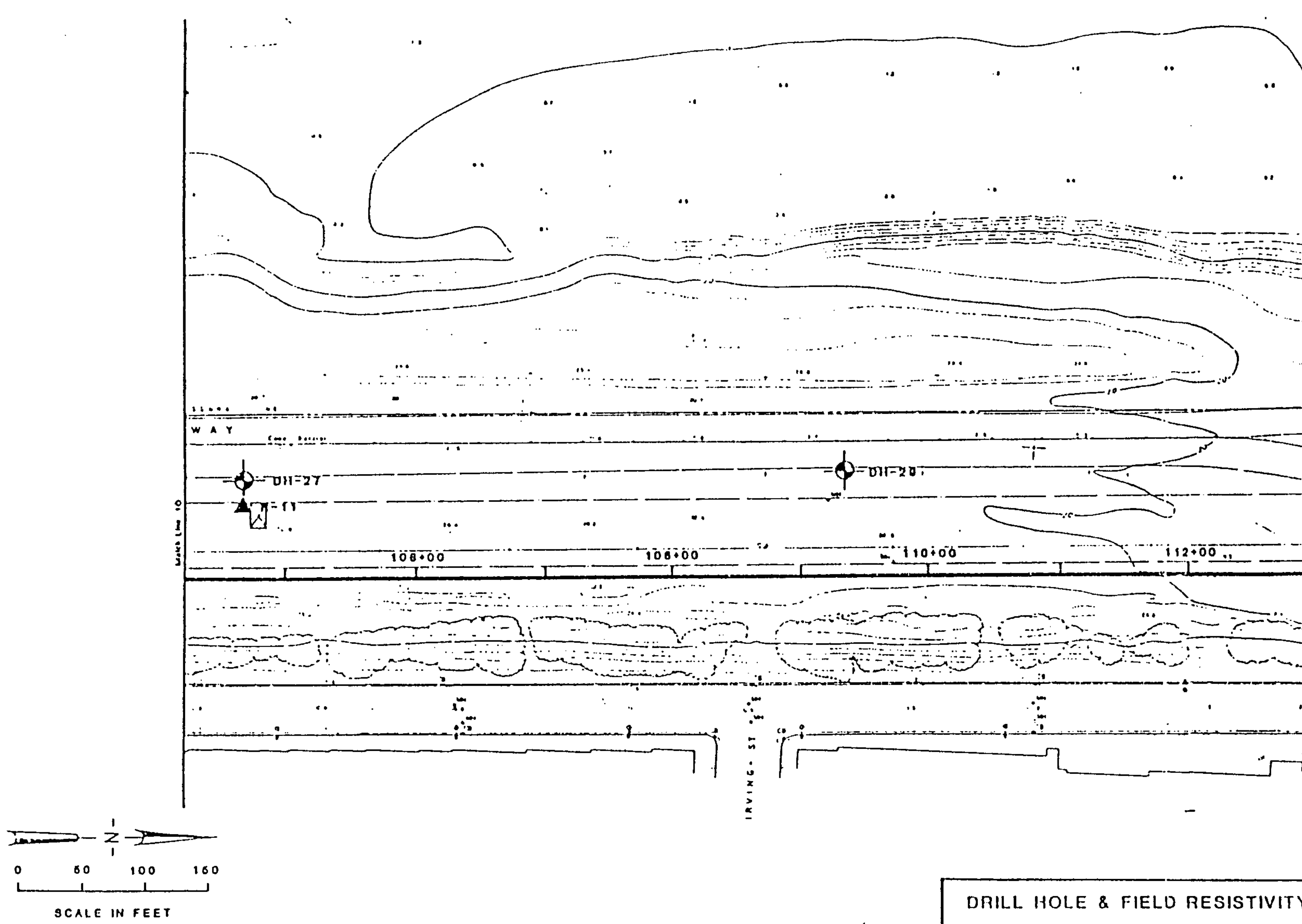
ADAPTED FROM SAN FRANCISCO CLEAN WATER PROGRAM
TOPOGRAPHIC DRAWING NO. 0 , JOB NO. 1107W

DRILL HOLE & FIELD RESISTIVITY TEST LOCATION MA		
NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841104	DATE: 6/1985	PLATE - 1.9



ADAPTED FROM SAN FRANCISCO CLEAN WATER PROGRAM
TOPOGRAPHIC DRAWING NO. 10, JOB NO. 1167W

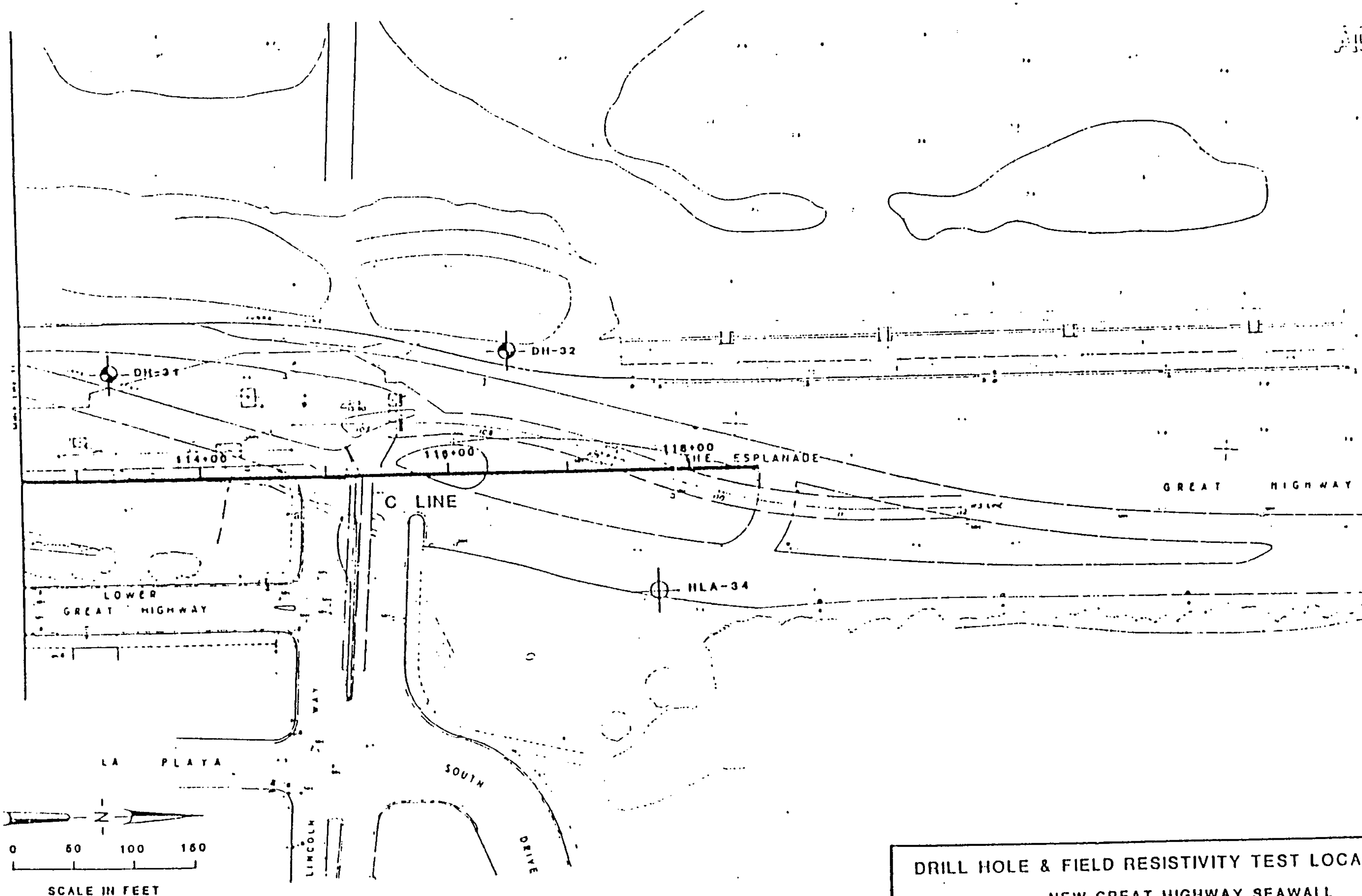
DRILL HOLE & FIELD RESISTIVITY TEST LOCATION MAP NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841104	DATE: 6/1985	PLATE - 1.10



ADAPTED FROM SAN FRANCISCO CLEAN WATER PROGRAM
TOPOGRAPHIC DRAWING NO. 1', JOB NO. 1107W

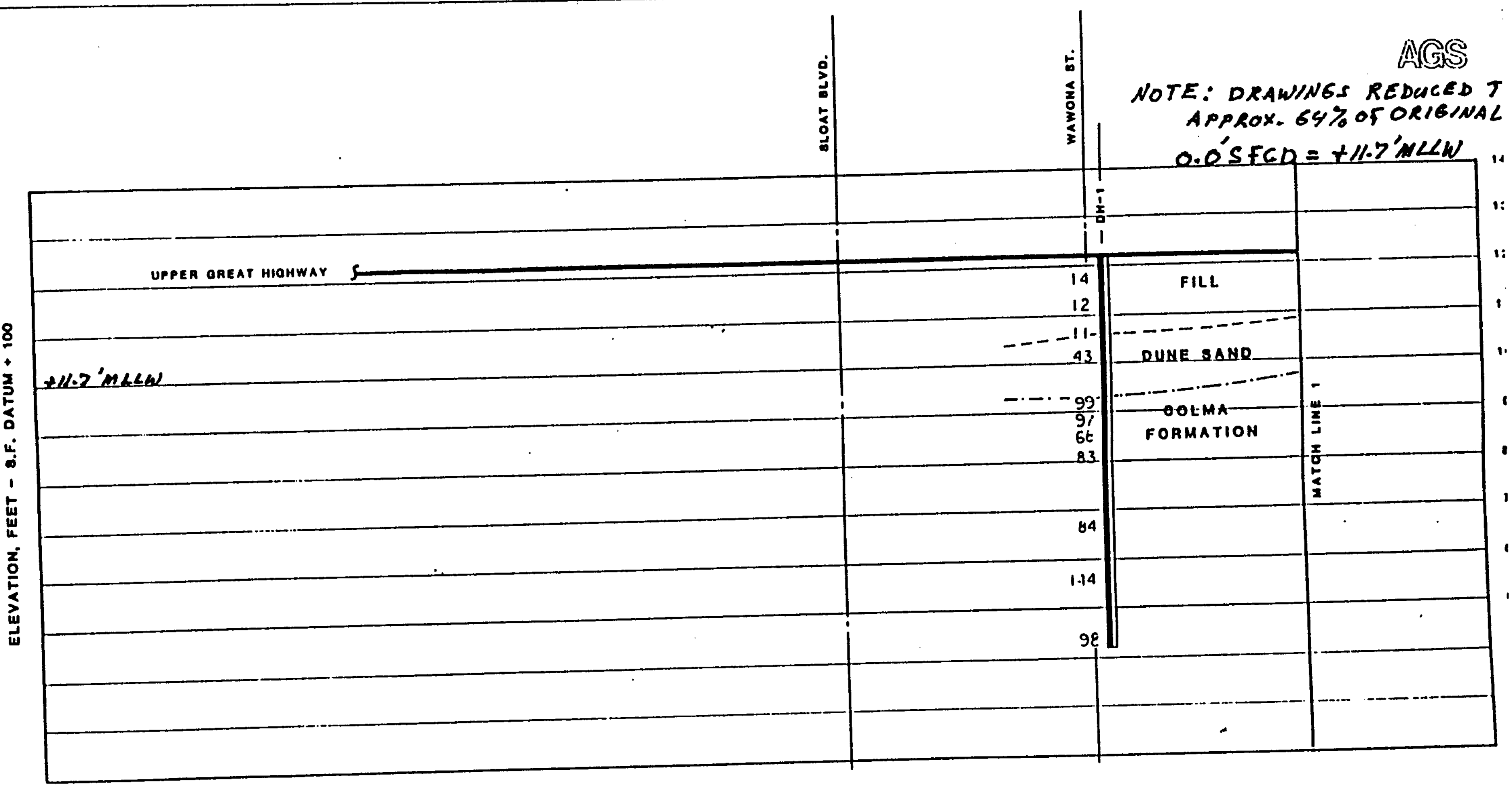
DRILL HOLE & FIELD RESISTIVITY TEST LOCATION MAP		
NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841101	DATE: 6/1985	PLATE - 1.11

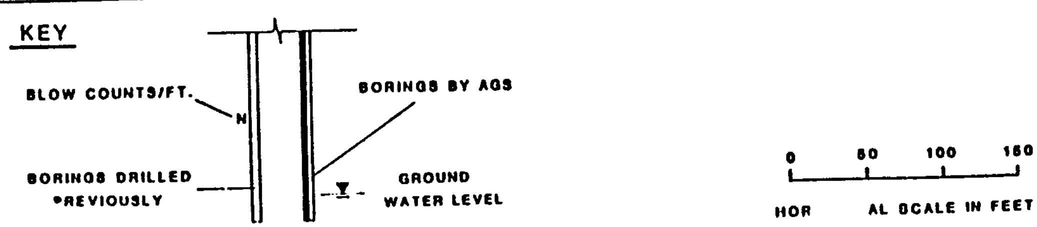
NOTE: DRAWINGS REDUCED TO APPROXIMATELY 64% OF ORIGINAL SIZE.



ADAPTED FROM SAN FRANCISCO CLEAN WATER PROGRAM
TOPOGRAPHIC DRAWING NO. 12, JOB NO. 1167W

DRILL HOLE & FIELD RESISTIVITY TEST LOCATION MAP		
NEW GREAT HIGHWAY SEAWALL		
JOB NO. 8F841104	DATE: 6/1985	PLATE - 1.12

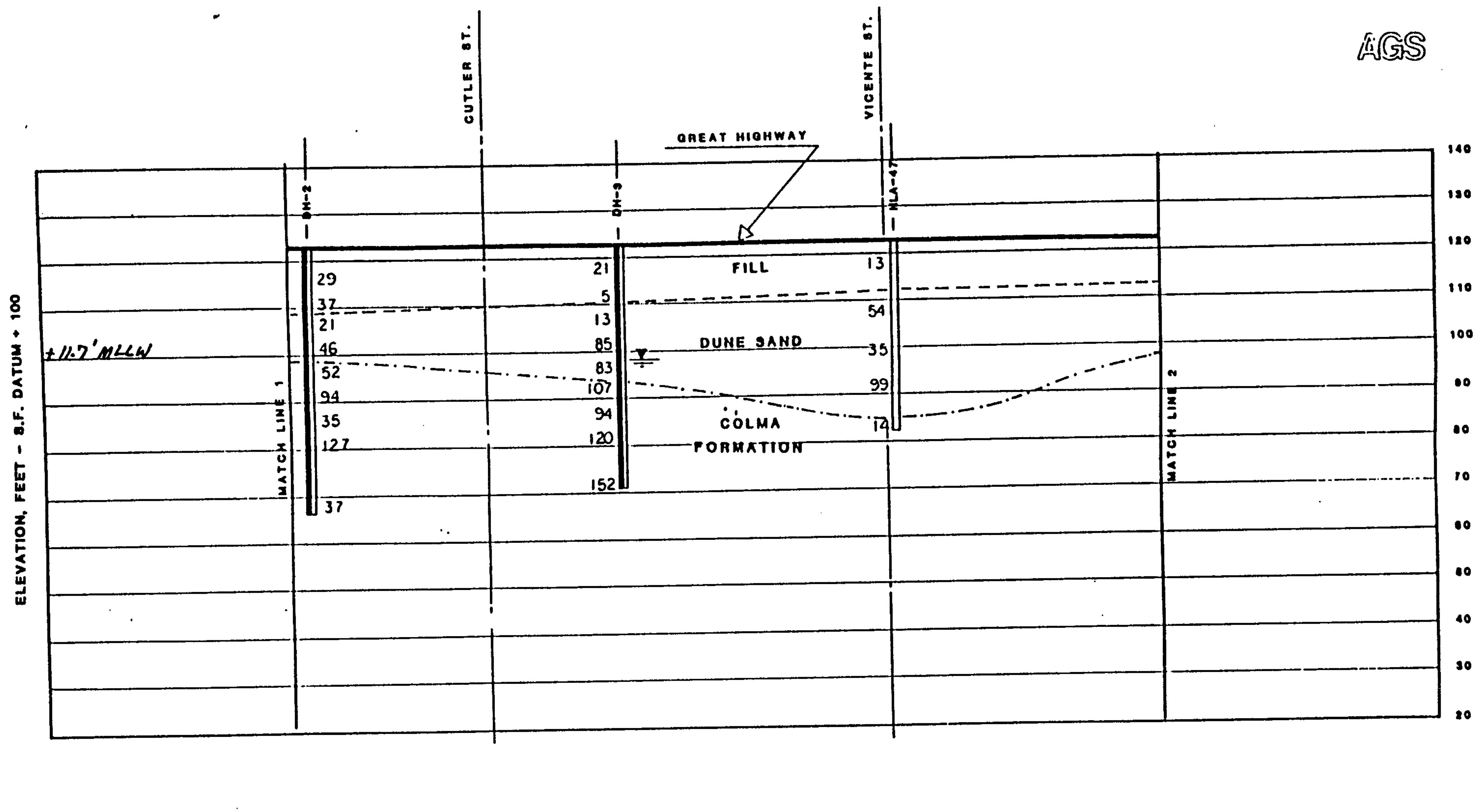




INTERPOLATED SUBSURFACE PROFILE

NEW GREAT HIGHWAY SEAWALL

JOB NO. SF841104	DATE: 6/1985	ATE - 2.1



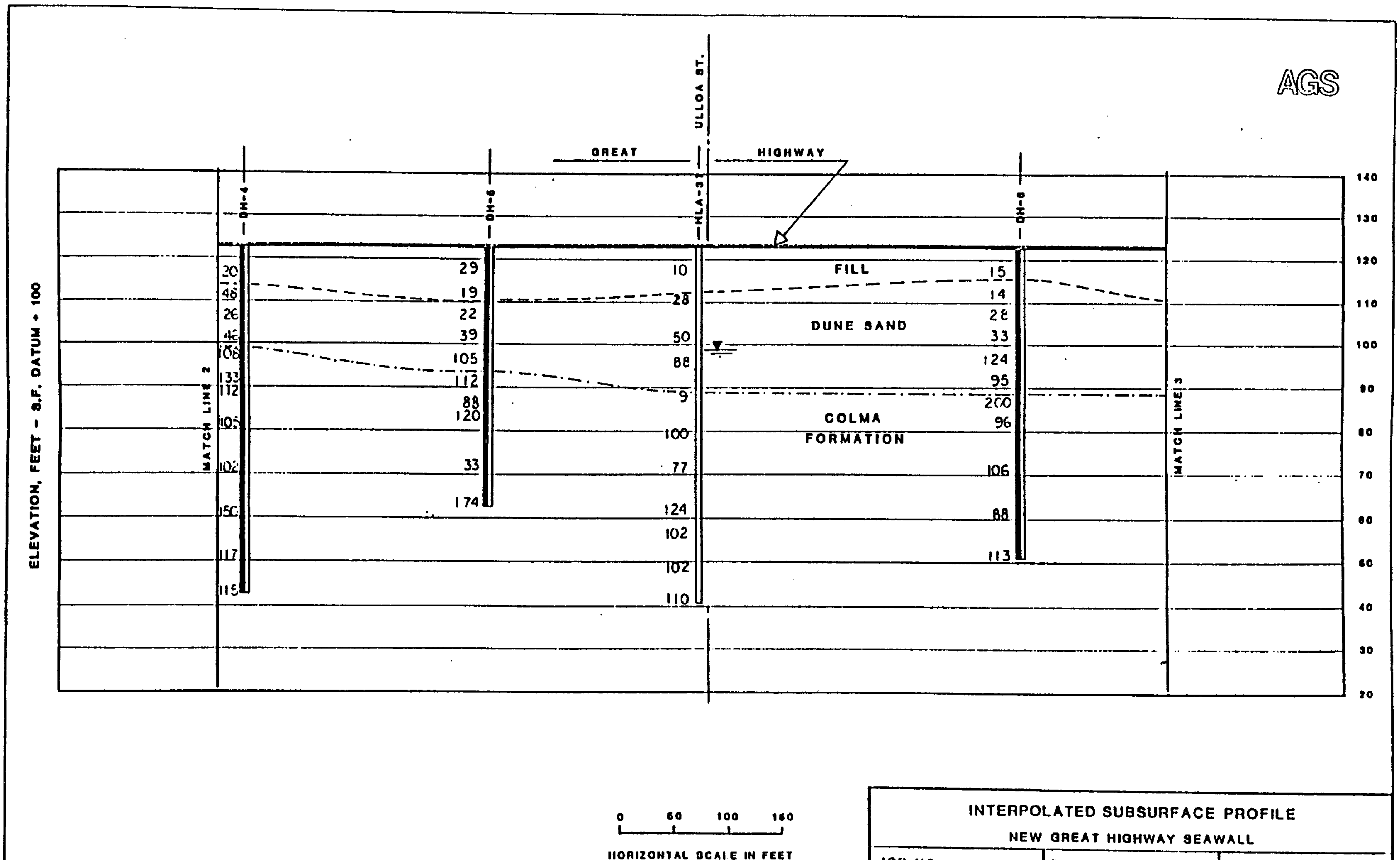
0 50 100 150

HORIZONT ·ALE IN FEET

INTERPOLATED SUBSURFACE PROFILE

NEW GREAT HIGHWAY SEAWALL

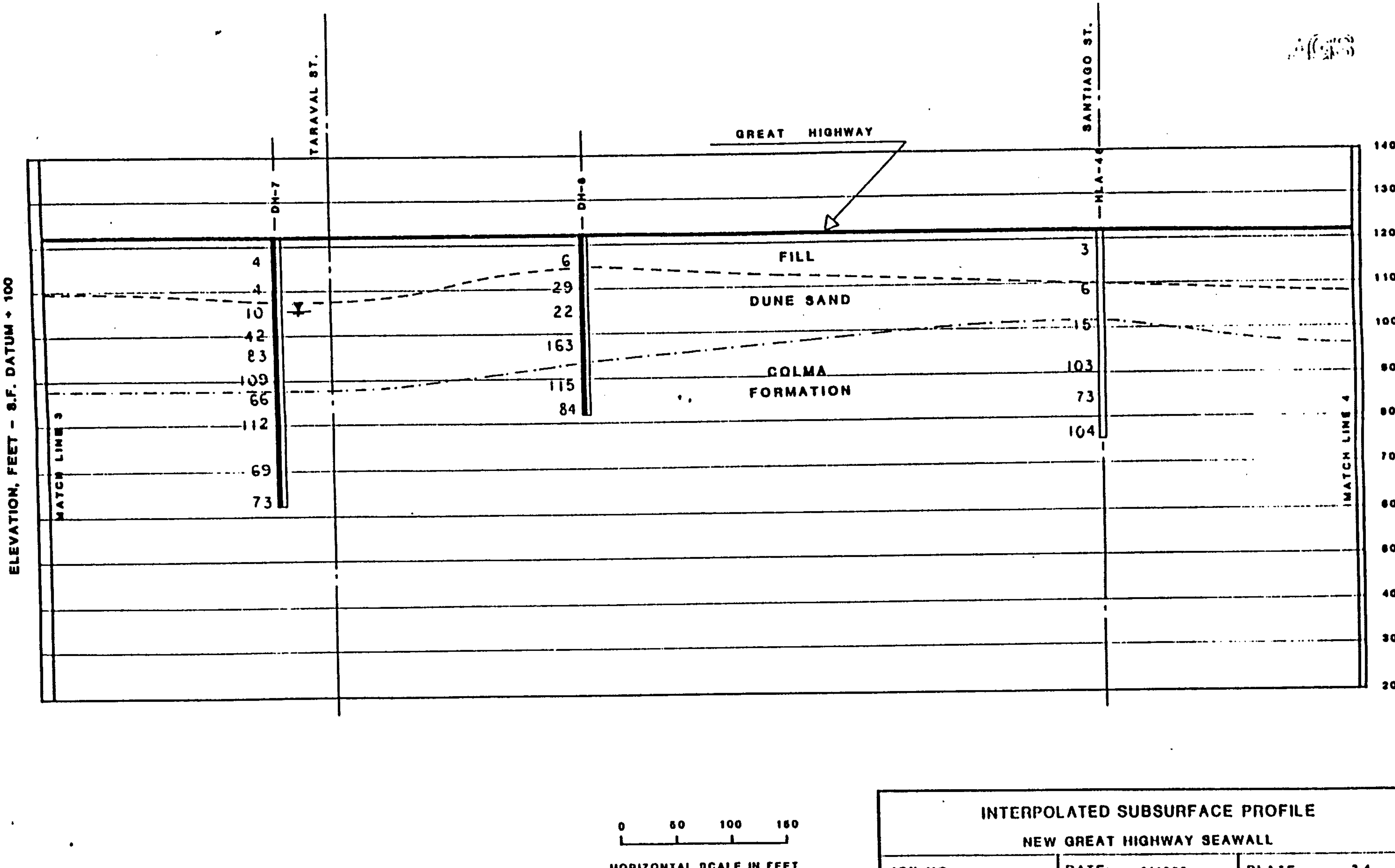
JOB NO. SF841104	DATE: 6/1985	PL' - 2.2



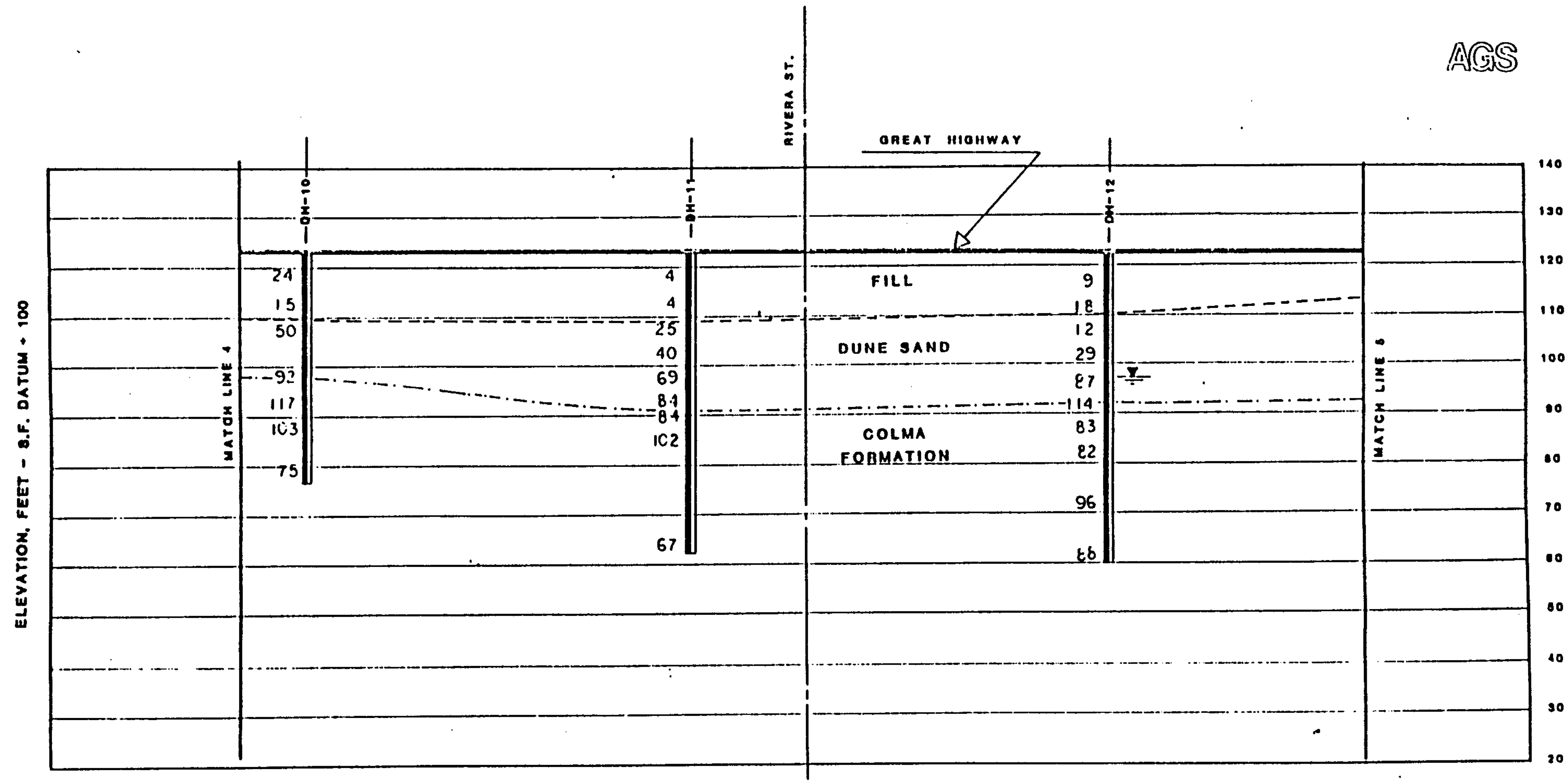
INTERPOLATED SUBSURFACE PROFILE

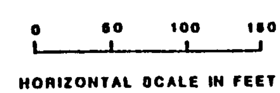
NEW GREAT HIGHWAY SEAWALL

JOB NO. SF841104	DATE: 6/1985	PLATE - 2.3



INTERPOLATED SUBSURFACE PROFILE		
NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841104	DATE: 6/1985	PLATE - 2.4

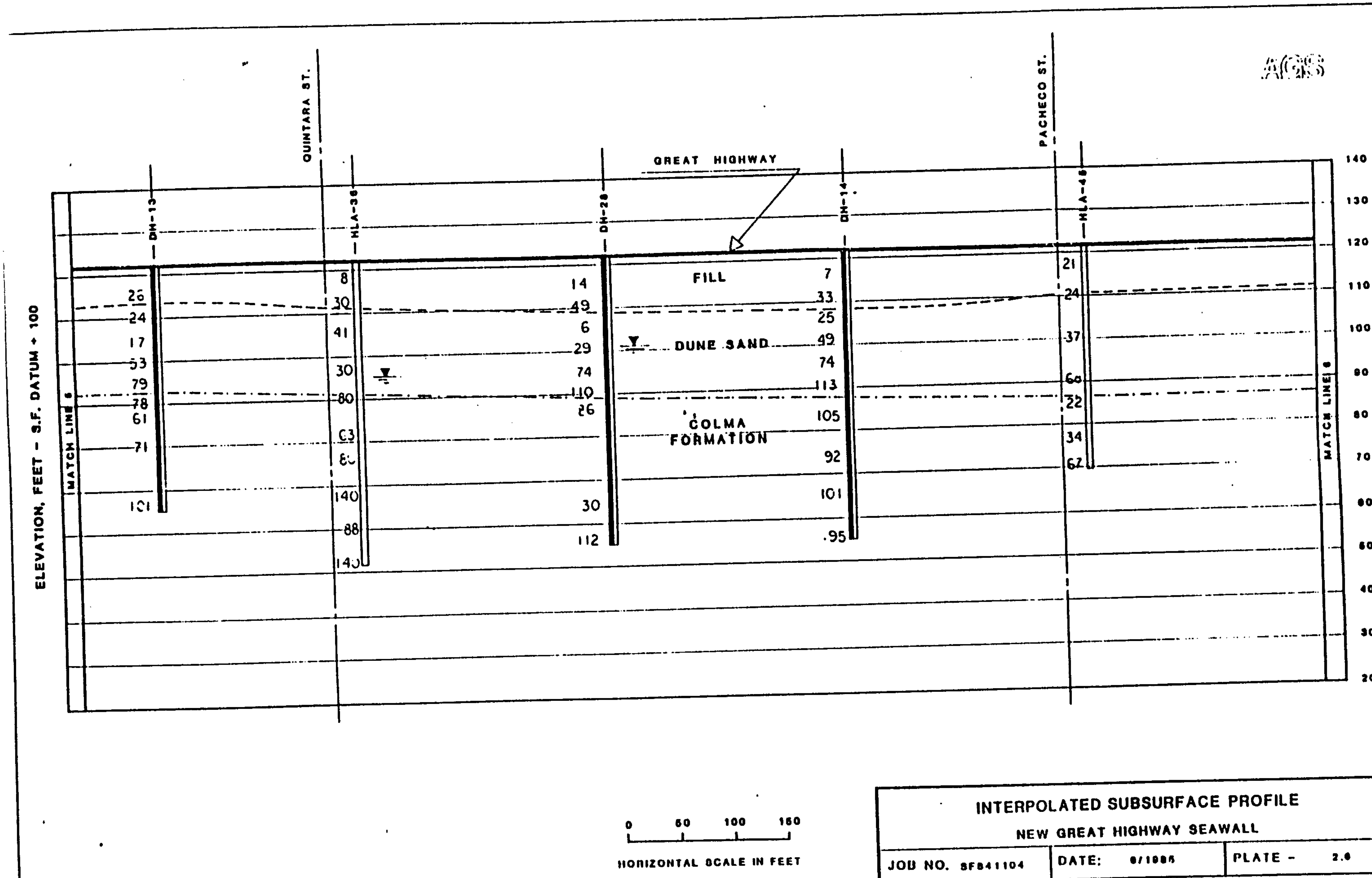




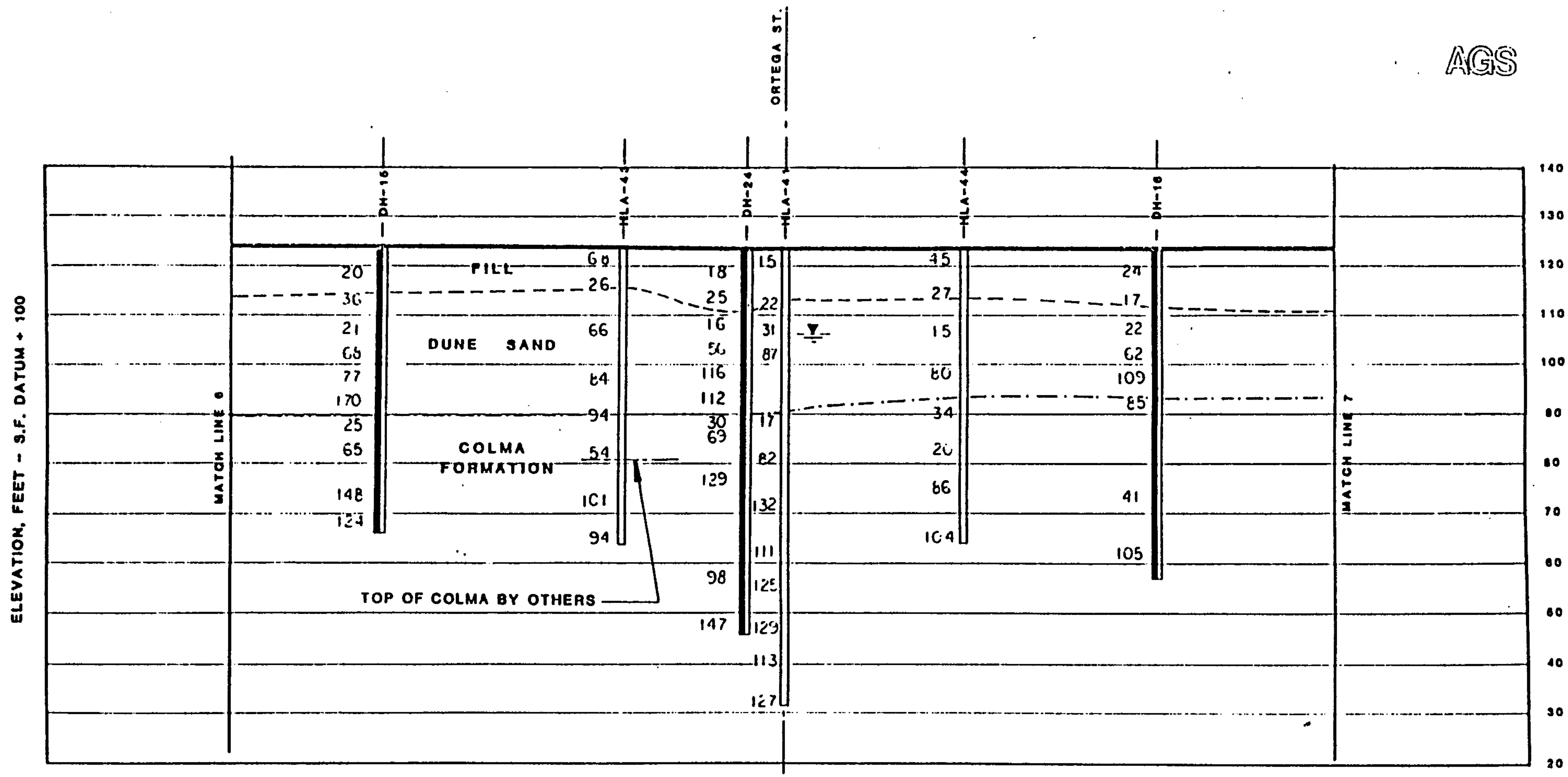
INTERPOLATED SUBSURFACE PROFILE

NEW GREAT HIGHWAY SEAWALL

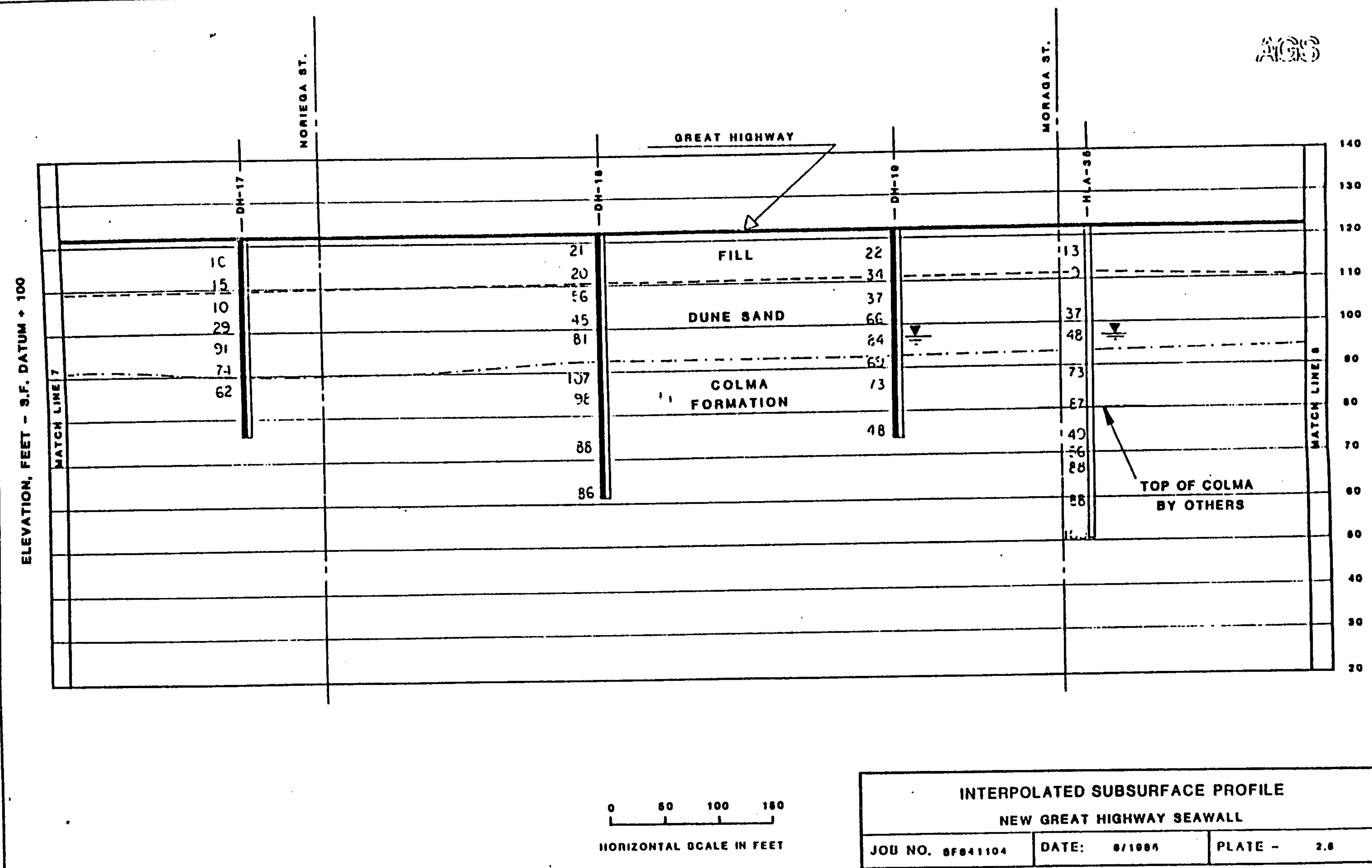
JOB NO. SF841104	DATE: 6/1985	PLATE - 2.6



INTERPOLATED SUBSURFACE PROFILE		
NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841104	DATE: 8/1985	PLATE - 2.6



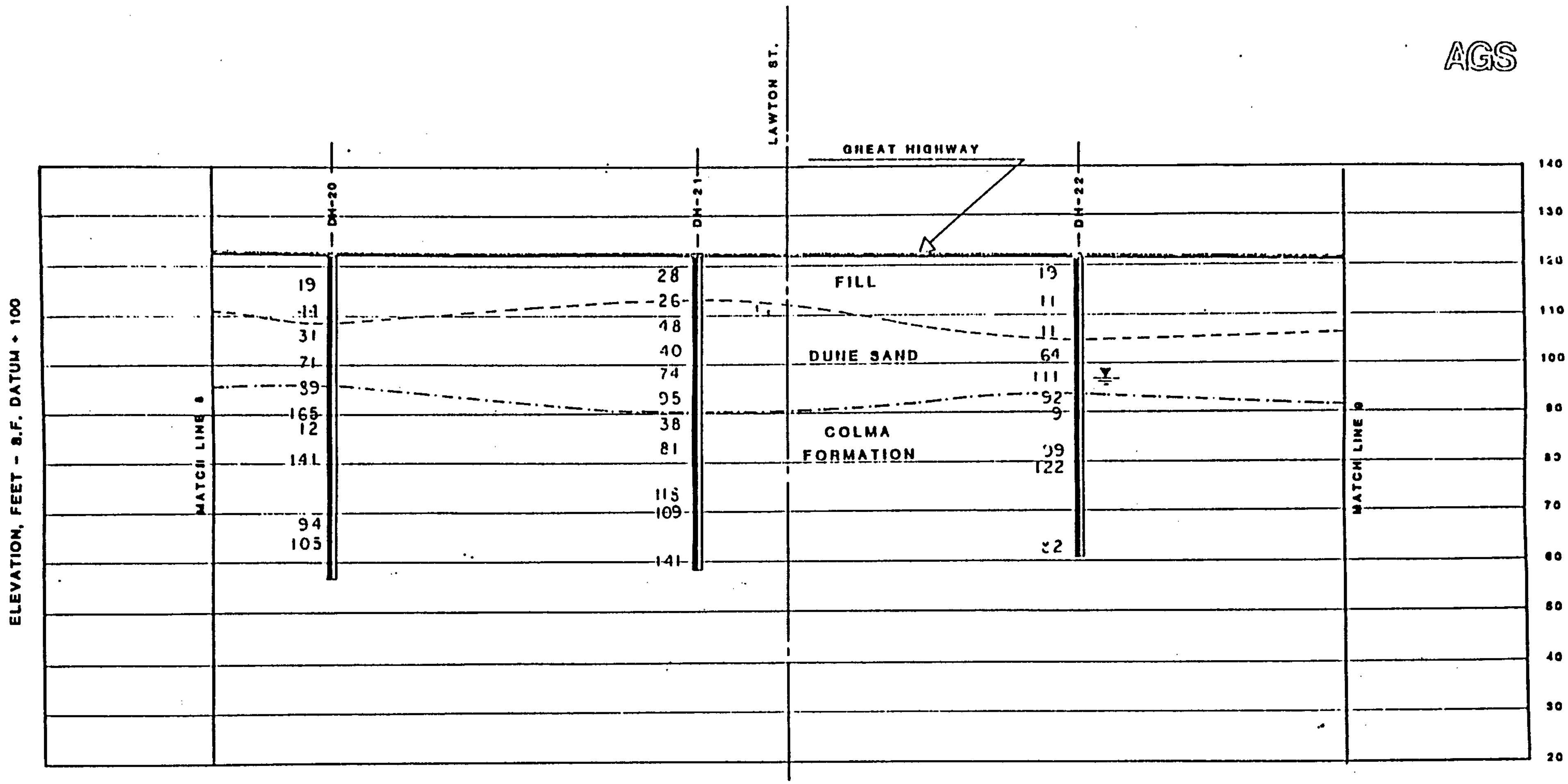
INTERPOLATED SUBSURFACE PROFILE		
NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841104	DATE: 8/1985	PLATE - 2.7



INTERPOLATED SUBSURFACE PROFILE

NEW GREAT HIGHWAY SEAWALL

JOB NO. 8F841104	DATE: 8/1986	PLATE - 2.8



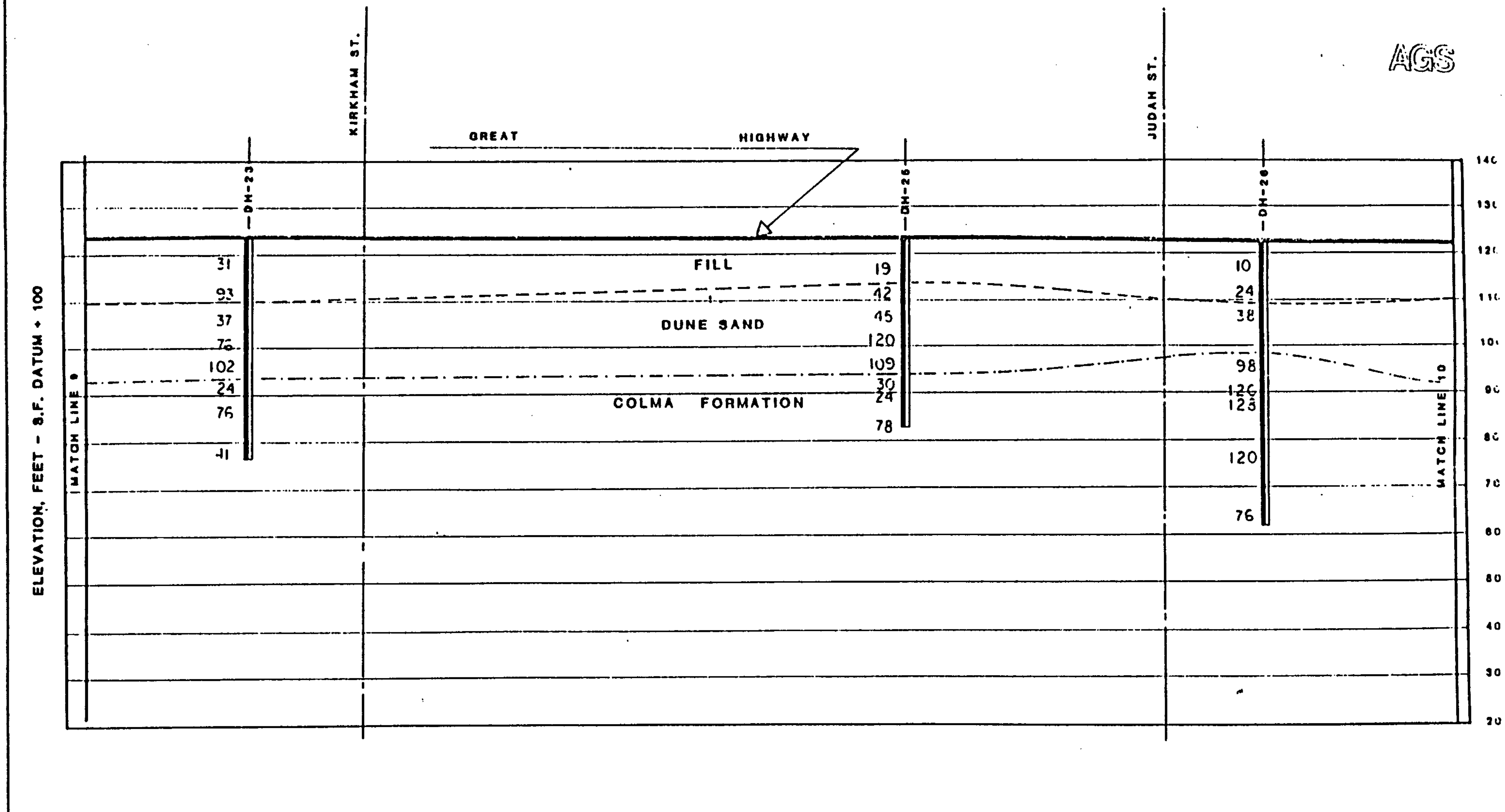
0 50 100 150

HORIZONTAL SCALE IN FEET

INTERPOLATED SUBSURFACE PROFILE

NEW GREAT HIGHWAY SEAWALL

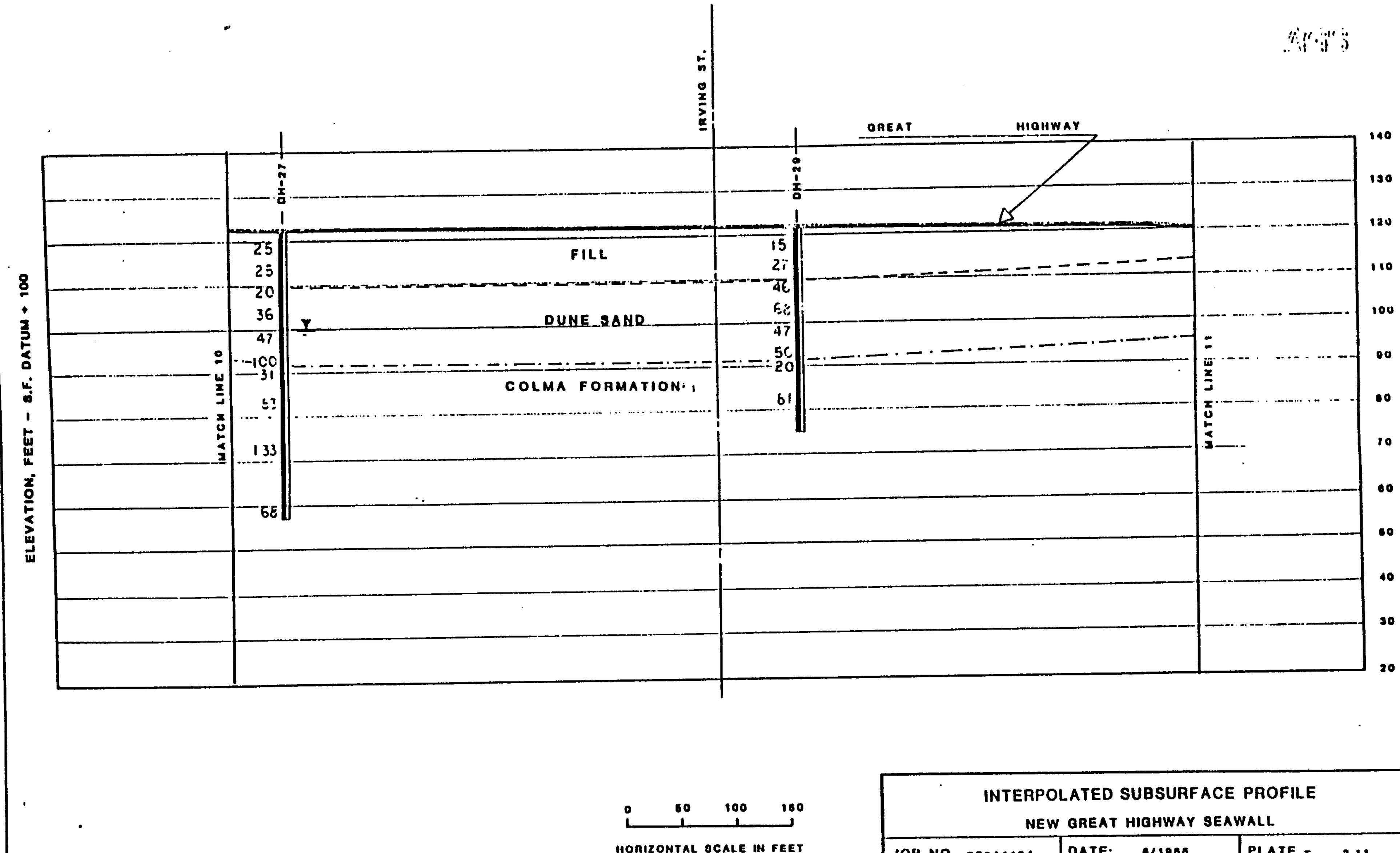
JOB NO. SF841104	DATE: 6/1985	PLATE - 2.9



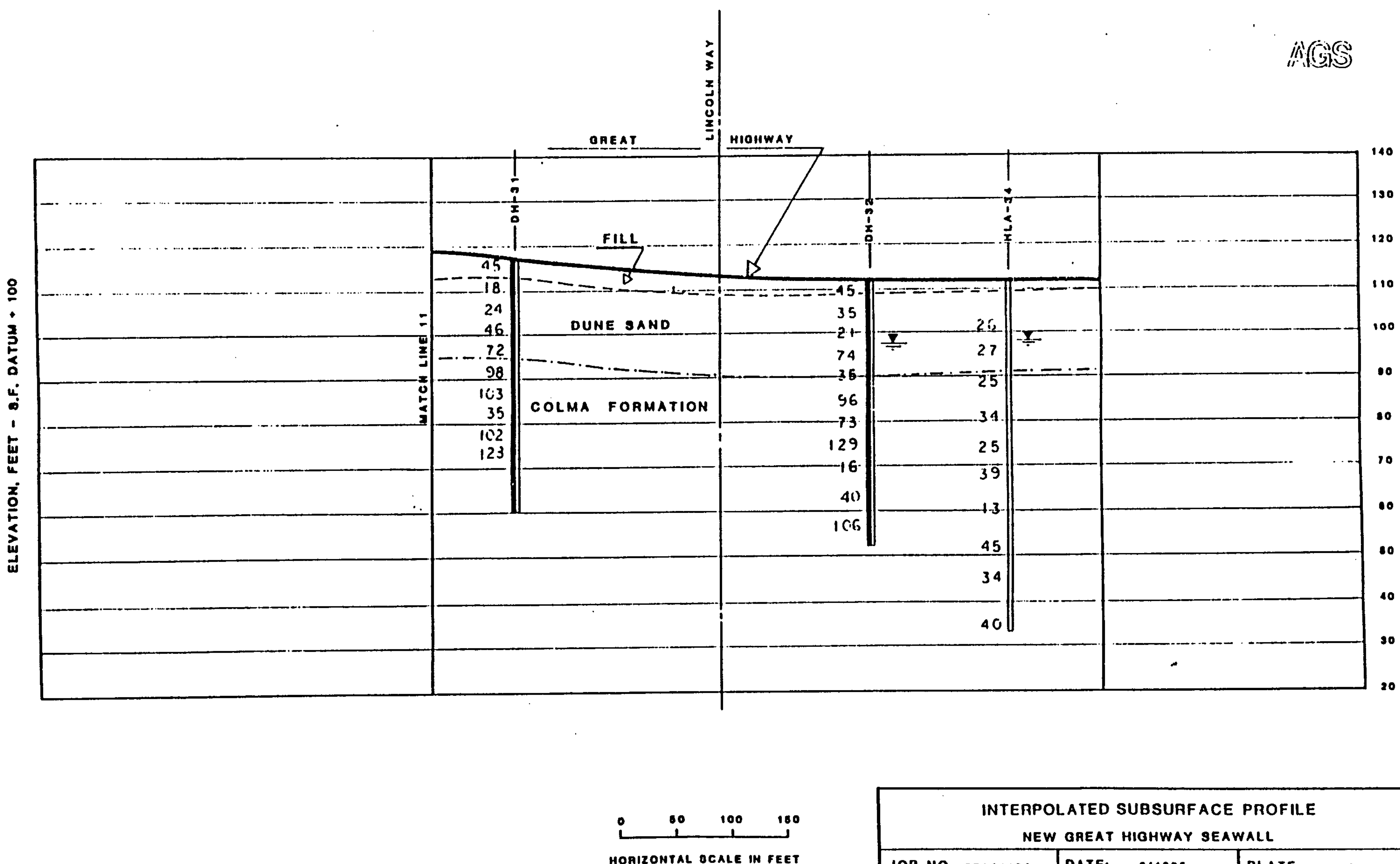
INTERPOLATED SUBSURFACE PROFILE

NEW GREAT HIGHWAY SEAWALL

JOB NO. SF841104	DATE: 6/1985	PLATE - 2.10



INTERPOLATED SUBSURFACE PROFILE NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841104	DATE: 6/1985	PLATE - 2.11



INTERPOLATED SUBSURFACE PROFILE		
NEW GREAT HIGHWAY SEAWALL		
JOB NO. SF841104	DATE: 6/1985	PLATE - 2.12

APPENDIX A

SUPPORTING GEOTECHNICAL DATA

EXPLORATION

Exploration for the new Great Highway seawall was performed from May 13, 1985 through June 6, 1985, and consisted of drilling of 30 borings, DH-1 through DH-32, excluding DH-9 and DH-30. The borings ranged in depth from 40 to 80 feet and were drilled at the locations shown on the Drill-Hole Location Map, Plates 1.1 through 1.12, as surveyed and marked by the Division of Surveys and Mapping of the Department of Public Works. Rotary-wash drilling equipment, provided by Pitcher Drilling Company was used. In addition, 8 borings were converted to ground-water monitoring wells and piezometers were installed.

The soils encountered were logged continuously in the field during drilling operations. Logs of borings presented on Plates A-1.1 through A-1.64 give descriptions of the earth materials encountered, show a graphic representation of the soil profile found, give the depth of which soil samples were obtained, indicate water levels, and field and laboratory tests performed. A legend to the logs is presented on Plate A-2.

SAMPLING

Three different types of samplers were utilized for soil sampling in this investigation which are tabulated below:

Sampler	Method of Advance	Sample Dimension
Standard split spoon (2" O.D.) or Standard Penetration Test Sampler	Driven by 140-pound hammer falling 30 inches	1-3/8-inch diameter x 18 inches

Modified California Sample Barrel (2-1/2" O.D.)	Driven by 400-pound hammer falling 18 inches	2-inch diameter x 18 inches
Pitcher Sampler (3" O.D.)	Thin-wall tube is forced into soil while core barrel outside tube reams out hole. Tube leads bit of core barrel an amount depending on consistency of soil. Tube prevented from rotating by ball bearing connection between tube and outer rotating barrel	3-inch diameter x 36 inches

Additionally, near surface bulk samples were also obtained. The samples were obtained generally by alternating between the Standard Penetration and the Modified California Samplers. Pitcher samples were obtained only at selected depths for each soil strata. The field blow counts for the Modified California Sampler were converted to an "Equivalent Standard Penetration Blow Counts" The converted blow counts are shown on the boring logs.

LABORATORY TESTING

A laboratory testing program was performed to determine the physical and engineering properties of the soils underlying the site.

MOISTURE AND DENSITY TESTS

Moisture content and density tests were performed on 103 samples to determine their consistencies and the moisture variation throughout the explored soil profile. The moisture content was determined in accordance with ASTM D2216, Standard Method for

Laboratory Determination of Water Content of Soil, Rock, and Soil-Aggregate Mixtures, and was considered to represent the moisture content of the entire sample for dry density determination. The test results are presented on the drill hole logs.

ATTERBERG LIMIT TESTS

Atterberg limit tests were performed on 6 representative samples to assist in the classification of subsurface soils. Liquid limits and plastic limits were determined in accordance with ASTM D423 and ASTM 3424. The test results are shown on the drill hole logs and Plates A-4.1 and A-4.2 of Appendix A.

DIRECT SHEAR TESTS

The strength parameters of the foundation soils were determined from two direct shear tests. The samples subjected to direct shear test were allowed access to water for at least 24 hours prior to testing, and then sheared in an undrained state at loads of 2, 3, 4 and 6 Kips. The results of direct shear tests are presented on Plates A-2.1 and A-2.2.

GRAIN-SIZE DISTRIBUTION TEST

63 wash sieve analysis tests and 17 gradation analysis tests were performed on the obtained samples to assist in the classification of subsurface soils and determination of the liquefaction potential. The tests were performed in accordance with ASTM D422. The results of wash tests and gradation tests are shown on drill hole logs and plates A-3.1 through A-3.9, respectively.

PERMEABILITY TESTS

Permeability tests were performed on two undisturbed samples for seepage evaluation underneath the seawall and also in order to determine the size of drain pipe. The results of permeability tests are presented in Table A-1 - Summary of Permeability Test Results.

TABLE A-1
SUMMARY OF
PERMEABILITY TEST RESULTS

Boring	Depth (feet)	% Passing # 200	Permeability (cm/sec)
DH-14	34	1.77	1.41×10^{-4}
DH-28	45	1.81	2.36×10^{-3}

SOIL RESISTIVITY AND CORROSION POTENTIAL

Resistivity is a fundamental property of materials and is defined as the resistance in ohm-centimeters between opposite faces of a unit cube of a material. The majority of electrical methods of exploration are based on differences in electrical conductivity or resistivity of a subsurface material. A field resistivity test consists of producing an electrical field in the ground by means of two current electrodes. By measuring the current and the potential drop between two intermediate electrodes, the apparent resistivity of the soil to a depth approximately equal to the spacing of the electrodes can be computed. Soil corrosivity increases with decreasing resistivity and increasing water content and/or water salinity.

The field resistivity survey for this investigation was performed using a Gossen Geohm-3 resistivity device. A total of 12 resistivity lines were completed; 1 along the east side of the upper Great Highway, 2 at the ocean edge, 5 on the beach along the bottom of the bluff, and 4 along the west side of the upper Great Highway at the top of the bluffs. The orientation of the survey lines were approxiamtely parallel to the Great Highway. Electrode spacing varied from 1 to 16 feet. The location of field resistivity tests are shown on Plates 1.1 through 1.12. Based on the resistivity data shown in Table A-2, the tests at the ocean edge show the soil to be corrosive to very corrosive (0-2000 Ohm-Cm). The remaining tests range from mildly corrosive to relatively noncorrosive

(2000 to 100,000 Ohm-Cm). Based on the obtained resistivity test results, we recommend that the effect of corrosivity upon the buried concrete structures be considered.

TABLE A-2

RESISTIVITY TEST RESULTS

Test No.	Station	Soil Resistivity (Ohm-Cm)	Soil Corrosivity
R-1	13+20	34,600	relatively noncorrosive
R-2	24+70	23,000	mildly corrosive
R-3	37+50	2,100	corrosive
R-4	37+50	1,500	very corrosive
R-5	54+20	1,100	very corrosive
R-6	70+60	23,000	mildly corrosive
R-7	81+60	1,000,000	noncorrosive
R-8	90+40	20,000	relatively noncorrosive
R-9	102+50	1,200	very corrosive
R-10	102+50	44,200	relatively noncorrosive
R-11	104+70	30,400	relatively noncorrosive
R-12	17+70	26,000	relatively noncorrosive

Reference: Underground Corrosion, ASTM Special Technical Publication 741, Nov. 1979.

Note: 0.0' SFCD = +11.7' MLLW

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-1
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/23/85
REFERENCE EL.: 20.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0			" ARTIFICIAL FILL (Qaf) " SAND (SP), brown, loose to medium dense, fine-grained. Baserock @ 0-1 ft.					
15.0		1	14						
				Grading slightly siltier @ 7½ ft. (2.1% passing No. 200 sieve)					
	10	2	12						SA
5.0		3	9	Subsurface void @ 15-16½ ft.	98	15			
				" DUNE SAND (Qd) " SAND (SP), brown, dense, fine-grained. Trace of organics and saturated at 21 ft.					
	20	4	43						
-5.0		5							
	30	6	81/9"	" COLMA FORMATION (Qc) " SAND (SP), dark gray to black, very dense, fine-grained. Trace of shells and gravel @ 33 ft. (2.8% passing No. 200 sieve)					SA
-15.0		7	97						

SHEET 1 OF 1

PLATE A- 1.1

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-1
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/23/85
REFERENCE EL.: 20.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35								
				" COLMA FORMATION (Qc) " PEAT (PT), dark brown, very stiff					
		8	68						
-20.0									
		9	83	" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), dark gray to gray-brown, very dense, fine-grained	114	18			
	45								
-30.0									
	55	10	84	Sea shells in sample @ 55 ft.					
-40.0									
	65	11	60/5"						
-50.0									

SHEET 2 OF 3

PLATE A- [illegible]

LOG OF DRILL HOLE

AGS

JECT: Great Highway Seawall
L HOLE NO.: DH-1
LING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/23/85
REFERENCE EL.: 20.0 ft.
DATUM: SFCD

DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
0					" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), gray-brown, very dense, fine-grained					
0										
0		12	98							
					Bottom of boring at 79½ ft. below the ground surface at approximately elevation-59½ ft. (SFCD)					

ET 3 OF 3 PLATE A- 1.3

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-2
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/24/85
REFERENCE EL.: 19.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0					" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, medium dense to dense, fine-grained Gravel @ 0-1 ft.					
14.5											
			1	29							
	10										
			2	37		Dense @ 11 ft.					
4.5						" DUNE SAND (Qd) " SAND (SP), brown, medium dense to dense, fine-grained					
			3	21							
	20										
			4	46		Saturated below 22 ft. (2.6% passing No. 200 sieve)					SA
-5.5											
			5	52		" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), dark gray to gray-brown, dense to very dense, fine-grained	131	16			
	30										
			6	86/11"		6 Inch lens of consolidated peat @ 32½ ft.					
-15.5											

SHEET 1 OF 7 PLATE A- 1.1

2

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-2
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/24/85
REFERENCE EL.: 19.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35	7	35	" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), dark gray to gray-brown, dense to very dense, fine-grained (9.4% passing No. 200 sieve)	108	18			SA
-20.5				Sea shells in sample @ 41 ft.					
		8	95/9"						
	45								
-30.5									
	55	9	37						
				Bottom of boring at 55½ ft. below the ground surface at approximately elevation-36 ft. (SFCD)					
-40.5									
	65								

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-3 (P)
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/22-23/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0	1		" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, loose to medium dense, fine-grained					
16.0		2	21						
	10	3	5	Grading slightly siltier @ 9 ft. Loose @ 10 ft.					
6.0		4	13	" DUNE SAND (Qd) " SAND (SP), light brown to brown, medium dense to very dense, fine-grained (1.7% passing No. 200 sieve)	95	4			SA
	20	5	85	Saturated below 20 ft.					
				6-7-85					
-4.0		6	83						
	30	7	98/11"	" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), brown to gray-brown, very dense, fine-grained (5.0% passing No. 200 sieve)					SA
-14.0									

LOG OF DRILL HOLE

AGS

JECT: Great Highway Seawall LOGGED BY: EH
L HOLE NO.: DH-3 (P) CHECKED BY: CS REFERENCE EL.: 21.0 ft.
LING METHOD: Rotary Wash DRILLING DATE: 5/22-23/85 DATUM: SFCD

DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
5	8	94	" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), gray-brown, very dense, fine-grained	135	14			
0	9	90/10"						
5								
0	10	114/9"						
5			Bottom of boring at 51½ ft. below the ground surface at approximately elevation-30½ ft. (SFCD) Piezometer Installed in boring					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-4 CHECKED BY: CS REFERENCE EL.: 21.5 ft.
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/28/85 DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0	1		" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, medium dense to dense, fine-grained Baserock @ 0-½ ft.					
16.5		2	20						
	10	3	48	" DUNE SAND (Qd) " SAND (SP), brown to dark brown, medium dense to dense, fine-grained					
6.5		4	26		105	6			
	20	5	46	Grading slightly siltier @ 20 ft. (2.7% passing No. 200 sieve)					SA
-3.5		6	108	" COLMA FORMATION (Qc) " SAND (SP), cemented, dark brown, very dense, fine-grained	116	15			
	30	7	100/9"	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), yellow-brown, very dense, fine to medium-grained (7.1% passing No. 200 sieve)					
-13.5		8	112		113	17			SA

SHEET 1 OF 3 PLATE A- 1.8

4

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-4 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/28/85
REFERENCE EL.: 21.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35					" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown, very dense, fine-grained					
-18.5			9	96/11"		Trace of gravel at 40 ft.					
	45										
-28.5			10	102			108	20			
	55										
-38.5			11	100/8"							
	65										
48 5											

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-4 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/28/85
REFERENCE EL.: 21.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	70		12	107/11"		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown, very dense, fine-grained					
-53.5											
	80		13	115							
						Bottom of boring at 80 ft. below the ground surface at approximately elevation-58½ ft. (SFCD)					

5

LOG OF DRILL HOLE

AGS

T: Great Highway Seawall LOGGED BY: EH
IOLE NO.: DH-5 CHECKED BY: CS
IG METHOD: Rotary Wash DRILLING DATE: 6/6/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
			" ARTIFICIAL FILL (Qaf) " SAND (SP), brown, medium dense, fine-grained					
1	29							
2	19							
			"DUNE SAND (Qd) " SAND (SP), brown, medium dense to very dense, fine-grained					
3	22							
4	39		Saturated below 20 ft.					
5	105			107	17			
			" COLMA FORMATION (Qc) " SAND (SP), red-brown, very dense, fine to medium-grained with some coarse sand (4.6% passing No. 200 sieve)					
6	93/10"							SA

1 OF 2 PLATE A-1.11

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-5 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 6/6/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET) DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
35		7	88			106	20			
			4		"COLMA FORMATION (Qc) " SANDY CLAY (CL), gray-brown, soft					SA
		8	50/5"		" COLMA FORMATION (Qc) " CLAYEY SAND (SC), gray-brown, very dense, fine to medium-grained (16.7% passing No. 200 sieve)					
-19.0										
45										
					" COLMA FORMATION (Qc) " SAND (SP), tan-brown, dense to very dense, fine to medium-grained (3.4% passing No. 200 sieve)					
-29.0		9	33			111	18			SA
55										
		10	87/6"							
-39.0					Bottom of boring at 59 ft. below the ground surface at approximately elevation-38 ft. (SFCD)					
65										

SHEET 2 OF 2 PLATE A-1.11

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-6
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/13/85
REFERENCE EL.: 21.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0	1		" ARTIFICIAL FILL (Qaf) " SAND (SP), brown, medium dense, fine-grained					
16.5		2	15						
	10	3	14	" DUNE SAND (Qd) " SAND (SP), gray-brown to light brown, medium dense to very dense, medium to fine-grained					
6.5		4	28						
	20	5	33	Saturated below 20 ft.	105	10			
-3.5		6	93/9"	Very dense below 25 ft. Grading slightly siltier @ 25 ft. (3.4% passing No. 200 sieve)					SA
	30	7	95						
-13.5				" COLMA FORMATION (Qc) "					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-6
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/13/85
REFERENCE EL.: 21.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35	8	200	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), yellow-brown to orange-brown, very dense, medium to fine-grained					
-18.5		9	96		110	21			
	45								
-28.5		10	106						
	55								
-38.5		11	88	" COLMA FORMATION (Qc) " SAND (SP), gray-brown, very dense, medium to fine-grained	105	22			
	65								
-48.5									

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LOG OF DRILL HOLE

AGS

:Great Highway Seawall LOGGED BY: EH
)LE NO.: DH-6 CHECKED BY: CS
; METHOD: Rotary Wash DRILLING DATE: 5/13/85

REFERENCE EL.: 21.5 ft.
DATUM: SFCD

SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
12	113		" COLMA FORMATION (Qc) " SAND (SP), gray-brown, very dense, medium to fine-grained					
			Bottom of boring at 71½ ft. below the ground surface at approximately elevation-50 ft. (SFCD)					

·T 3 OF 3

PLATE A- 1.15

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-7(P) CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 6/4-5/85

REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0				" ARTIFICIAL FILL (Qaf) " SAND (SP), brown, loose, fine-grained					
16.0		1	4							
	10	2	4							
						101	17			
6.0		3	10		" DUNE SAND (Qd) " SAND (SP), brown, medium dense to very dense, fine-grained					
	20	4	42		Saturated below 19 ft.					
					6-7-85					
-4.0		5	83		(2.3% passing No. 200 sieve)	98	20			SA
	30	6	91/10"		(4.4% passing No. 200 sieve)					SA
-14.0		7	66		" COLMA FORMATION (Qc) " (4.1% passing No. 200 sieve)	100	23			SA

SHEET . OF

8

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-7(P)
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 6/4-5/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET) DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
35			" COLMA FORMATION (Qc) " SAND (SP), brown, very dense, fine-grained with some gravel					
-19.0	8	93/10"	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown, very dense, fine-grained (6.7% passing No. 200 sieve)					SA
45			Color change to light brown at 43 ft.					
-29.0	9	69		103	23			
55			Color change to red-brown at 55 ft.					
-39.0	10	73						
			Bottom of boring at 59½ ft. below the ground surface at approximately elevation-38½ ft. (SFCD)					
65			Piezometer installed in boring					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-8
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/13-14/85
REFERENCE EL.: 21.5 ft.
DATUM: SFCD

ELEVATION (FEET) DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
0	1		" ARTIFICIAL FILL (Qaf) " SAND (SP), brown, very loose to loose, fine-grained with some clay @ 0-1½ ft.					
16.5								
	2	6						
10			" DUNE SAND (Qd) " SAND (SP), gray-brown, medium dense to very dense, fine-grained					
	3	29						
6.5								
	4	22	(3.7% passing No. 200 sieve)	108	4			SA
20			Saturated below 20 ft.					
-3.5								
	5	163	Very dense below 25 ft. (4.1% passing No. 200 sieve) Gravel lens @ 28 ft.					SA
30			" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown to yellow-brown, very dense, medium to fine-grained					
	6	115		103	20			
-13.5								

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LOG OF DRILL HOLE

AGS

CT: Great Highway Seawall LOGGED BY: EH
HOLE NO.: DH-8 CHECKED BY: CS
NG METHOD: Rotary Wash DRILLING DATE: 5/13-14/85
REFERENCE EL.: 21.5 ft.
DATUM: SFCD

SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	7	84		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), yellow-brown, very dense, medium to fine-grained (11.1% passing No. 200 sieve)	106	22			SA
				Bottom of boring at 40 ft. below the ground surface at approximately elevation-18½ ft. (SFCD)					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-10 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/14/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0		1			" ARTIFICIAL FILL (Qaf) " SAND (SP), brown, medium dense, medium to fine-grained Baserock @ 0-1 ft. Some small gravel in sand @ 4 ft.					
16.0			2	24							
	10		3	15			100	5			
6.0			4	50		" DUNE SAND (Qd) " SAND (SP), brown, very dense, medium to fine-grained					
	20		5			Saturated below 21 ft.					
-4.0			6	92		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), brown to orange-brown, very dense, medium to fine-grained (6.9% passing No. 200 sieve)	106	19			SA
	30			88/9"							
-14.0											

SHEET 1 OF 2

PLATE A- 1.70

10

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-10
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 5/14/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET) DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
35	8	103	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown, very dense, medium to fine-grained	106	21			
-19.0			Trace of gravel @ 35 ft.					
45	9	75						
			Bottom of boring at 46 ft. below the ground surface at approximately elevation-25 ft. (SFCD)					
-29.0								
55								

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-11
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 6/4/85
REFERENCE EL.: 20.5 ft.
DATUM: SFCD

ELEVATION (FEET) DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
0			" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, loose, fine-grained					
15.5	1	4	Baserock at 0-2 ft.					
10	2	4						
5.5	3	25	" DUNE SAND (Qd) " SAND (SP), brown, medium dense to very dense, fine-grained					
20	4	40	Saturated below 20 ft.					
-4.5	5	69	(3.0% passing No. 200 sieve)	97	21			SA
30	6	84						
-14.5	7	84	" COLMA FORMATION (Qc) " SAND (SP), red-brown, very dense, fine to medium-grained with some coarse sand					SA

LOG OF DRILL HOLE

AGS

:Great Highway Seawall LOGGED BY: EH
)LE NO.: DH-11 CHECKED BY: CS
; METHOD: Rotary Wash DRILLING DATE: 6/4/85

REFERENCE EL.: 20.5 ft.
DATUM: SFCD

SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
			(3.8% passing No. 200 sieve)					
8	85/10"		" COLMA FORMATION (Qc) " CLAYEY SAND (SC), brown, very dense, fine-grained (17.1% passing No. 200 sieve)					SA
9				98	26			DS
10	67		" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), gray-brown, very dense, fine-grained	102	24			
			Bottom of boring at 60½ ft. below the ground surface at approximately elevation-40 ft. (SFCD)					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-12 (P) CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/13/85

REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0	1			" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, loose, fine-grained Baserock @ 0-1½ ft.					
16.0		2	9			95	3			
	10	3	18		(1.5% passing No. 200 sieve)					SA
6.0		4	12		" DUNE SAND (Qd) " SAND (SP), grayish brown, medium dense to very dense, medium to fine-grained					
	20	5, 6	29		Saturated @ 20 ft.	100	13			
					Grading slightly siltier @ 23 ft.					
-4.0		7	87		Very dense below 25 ft. (3.4% passing No. 200 sieve) 6-7-85					SA
	30	8, 9	114		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown to gray-brown, very dense, medium to fine-grained	103	20			
-14.0										

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-12 (P) CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/13/85

REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35	10	83		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown to gray-brown, very dense, medium to fine-grained					
-19.0		11	82			105	22			
	45									
-29.0		12	96							
	55									
-39.0		13	88							
	65				Bottom of boring at 61½ ft. below the ground surface at approximately elevation-40½ ft. (SFCD) Piezometer Installed In boring					

SHEET 2 OF 2

PLATE A- 1.25

13

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-13 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/24/85

REFERENCE EL.: 21.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0				" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, medium dense, fine-grained Baserock @ 0-1 ft.					
16.5		1	26							
	10	2	24		" DUNE SAND (Qd) " SAND (SP), brown, medium dense to very dense, fine-grained					
6.5		3	17			93	9			
	20	4	53		Very dense below 20 ft.					
-3.5		5	79		Saturated below 25 ft.	103	20			
	30	6	65/10"		" COLMA FORMATION (Qc) " SAND (SP), brown to yellow-brown, very dense, fine to medium-grained, with traces of gravel (4.1% passing No. 200 sieve) Medium to coarse-grained sand @ 35-39 ft.					SA
-13.5		7	61			112	18			

SHEET 1 OF 2

PLATE A- 1.24

LOG OF DRILL HOLE

AGS

ECT: Great Highway Seawall
L HOLE NO.: DH-13
LING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/24/85
REFERENCE EL.: 21.5 ft.
DATUM: SFCD

DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
5			" COLMA FORMATION (Qc) " SAND (SP), yellow-brown, very dense, medium to coarse-grained					
5			Grading clayey @ 40 ft.					
	8	71	" COLMA FORMATION (Qc) " SANDY CLAY (CL), green-brown, hard (79.3% passing No. 200 sieve)					SA
5								
5								
55	9	93/11"	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), yellow-brown, very dense, fine-grained					
			Bottom of boring at 54½ ft. below the ground surface at approximately elevation-33 ft. (SFCD)					

PLATE A- 1.27

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-14
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 6/5/85
REFERENCE EL.: 20.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0			" ARTIFICIAL FILL (Qaf) " SAND (SP), brown, loose to dense, fine-grained					
15.5		1	7	Baserock at 0-2 ft.					
	10	2	33						
5.5		3	25	" DUNE SAND (Qd) " SAND (SP), light brown to brown, medium dense to very dense, fine-grained					
	20	4	49						
				Saturated below 24 ft.					
-4.5		5	74						
	30	6	93/10"	(3.7% passing No. 200 sieve)					SA
				" COLMA FORMATION (Qc) " SAND (SP), red-brown, very dense, medium-grained (1.8% passing No. 200 sieve)					SA, P
-14.5		7							

PLATE A- 1.28

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-15
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 5/15/85
REFERENCE EL.: 20.5 ft.
DATUM: SFCD

ELEVATION (FEET) DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
35	8, 9	20	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), with some organics, dark gray, medium dense to very dense (26.4% passing No. 200 sieve)	114	17	24	15	SA
-19.5	10	65	Very dense below 40 ft. (18.1% passing No. 200 sieve)	114	18			SA
45								
-29.5	11	99/8"						
55	12	114/11"	"COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), yellow-brown, very dense, medium to fine-grained	116	17			
			Bottom of boring 56½ ft. below the ground surface at approximately elevation- 36 ft. (SFCD)					
-39.5								
65								

SHEET 2 OF 2

PLATE A- 1.31

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-16
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 5/31/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET) DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
0			" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, medium dense, fine-grained Baserock @ 0-2 ft.					
16.0	1	24						
10	2	17						
6.0	3	22	" DUNE SAND (Qd) " SAND (SP), light brown to brown, medium dense to very dense, fine-grained	103	11			
20	4	62	Saturated and very dense below 20 ft. (3.9% passing No. 200 sieve)					SA
-4.0	5	109		101	21			
30	6	85	" COLMA FORMATION (Qc) " SAND (SP), cemented, brown, very dense, fine to medium-grained (4.4% passing No. 200 sieve)					SA
-14.0								

15

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-14 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 6/5/85

REFERENCE EL.: 20.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35			" COLMA FORMATION (Qc) " SAND (SP), red-brown, very dense, medium-grained					
-19.5		8	105	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), red-brown, very dense, fine to medium-grained (8.0% passing No. 200 sieve)					SA
-29.5	45	9	84/11"	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), orange-brown, very dense, fine-grained (49.5% passing NO. 200 sieve)			28	16	SA
-39.5	55	10	93/11"	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), red-brown, very dense, fine-grained	110	19			
	65	11	95/11"						
				Bottom of boring at 66½ ft. below the ground surface at approximately elevation-46 ft. (SFCD)					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-15 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/15/85

REFERENCE EL.: 20.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL
	0	1		" ARTIFICIAL FILL (Qaf) " SAND (SP), brown to light brown, medium dense, fine-grained Baserock @ 0-1 ft.					
15.5		2	20						
	10	3	36	" DUNE SAND (Qd) " SAND (SP), gray-brown, medium dense to very dense, fine-grained (1.7% passing No. 200 sieve)					
5.5		4	21		110	13			
	20	5	68	Very dense and saturated below 20 ft. Trace of shells at 20'					
-4.5		6	77		106	19			
	30	7	113/8"	(1.7% passing No. 200 sieve)					
-14.5				" COLMA FORMATION (Qc) "					

16

PLATE A 1.29

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-16 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/31/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35			" COLMA FORMATION (Qc) " SAND (SP), cemented, brown, very dense, fine to medium-grained					
-19.0		7		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), brown to light brown, dense to very dense, fine-grained					
	45								
-29.0		8	41	Color change to dark gray at 50 ft. (8.0% passing No. 200 sieve)	106	24			SA
	55			Color change to gray at 55 ft.					
-39.0		9	105	Grading less clayey and light brown at 60 ft.	115	16			
	65			Bottom of boring at 65 ft. below the ground surface at approximately elevation-44 ft. (SFCD)					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-17 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/16/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0			" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, loose to medium dense, fine-grained Baserock @ 0-1 ft.					
16.0		1	10	Grading slightly siltier @ 7 ft.	92	2			
	10	2	15						
6.0		3	10	" DUNE SAND (Qd) " SAND (SP), brown, loose to very dense, fine-grained (1.6% passing No. 200 sieve)					SA
	20	4	29	Saturated below 19 ft. (3.6% passing No. 200 sieve)	103	14			SA
-4.0		5	91	Very dense below 24 ft.					
	30	6	74						
-14.0		7	62	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), mottled orange-brown and gray-brown, very dense					

17

LOG OF DRILL HOLE

AGS

T: Great Highway Seawall LOGGED BY: EH
IOLE NO.: DH-17 CHECKED BY: CS
IG METHOD Rotary Wash DRILLING DATE: 5/16/85

REFERENCE EL.: 21.0 ft.
DATUM: SFCD

SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
7		" COLMA FORMATION (Qc) " CLAYEY SAND (SC), mottled orange-brown and gray-brown, very dense (17.7% passing No. 200 sieve)	111	18			SA
		Grading to yellow-brown at 41 ft.					
8			101	18			DS
		Bottom of boring at 44½ ft. below the ground surface at approximately elevation- 23½ ft. (SFCD)					

ET 2 OF 2

PLATE A- 1.35

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-18 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/30-31/85

REFERENCE EL.: 20.0 ft.
DATUM: SFCD

ELEVATION (FEET) DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
0			" ARTIFICIAL FILL (Qaf) " SAND (SP), brown, medium dense, fine-grained					
	1	21						
15.0								
10	2	20						
			" DUNE SAND (Qd) " SAND (SP), brown, dense to very dense, fine-grained					
	3	56						
5.0								
				105	19			
	4	45						
20								
			Saturated below 23 ft.					
	5	81						
-5.0								
30	6		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), light brown, very dense, fine-grained					
	7	80/10"	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), gray, very dense, fine-grained					
-15.0								

SHEET 1 OF 2

PLATE A- 1.36

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-18 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/30-31/85
REFERENCE EL.: 20.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35								
		8	98	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown, very dense, fine-grained (8.7% passing No. 200 sieve)	109	20			SA
-20.0									
	45								
		9	81 11						
-30.0									
	55			" COLMA FORMATION (Qc) " CLAYEY SAND (SC), orange-brown, very dense, fine-grained					
		10	86	(32.9% passing No. 200 sieve)	116	17			SA
-40.0				Bottom of boring at 60 ft. below the ground surface at approximately elevation-40 ft. (SFCD)					
	65								

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-19 (P) CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/16/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0	1		" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, medium dense, fine-grained					
16.0									
		2	22	(2.6% passing No. 200 sieve)					SA
				Grading slightly siltier @ 8 ft.					
	10	3	34	(1.7% passing No. 200 sieve)					SA
				" DUNE SAND (Qd) " SAND (SP), light brown to brown, dense to very dense, fine-grained					
6.0									
		4	37		103	4			
	20			Grading slightly siltier @ 19 ft. Very dense and saturated below 20 ft.					
		5	66	(4.8% passing No. 200 sieve)					SA
				6-7-85					
-4.0									
		6	84	Color change to dark brown at 26 ft. (5.4% passing No. 200 sieve)	120	16			SA
	30								
		7	69	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), orange-brown, very dense (16.7% passing No. 200 sieve)					SA
-14.0				" COLMA FORMATION (Qc) "					

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LOG OF DRILL HOLE

AGS

:Great Highway Seawall LOGGED BY: EH
OLE NO.: DH-19 (P) CHECKED BY: CS
G METHOD: Rotary Wash DRILLING DATE: 5/16/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
8	73		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown, very dense, fine to medium-grained	110	20			
9	48			109	19			
			Bottom of boring 46½ ft. below the ground surface at approximately elevation-25½ ft. (SFCD) Piezometer installed in boring					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-20 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/22/85
REFERENCE EL.: 20.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0				" ARTIFICIAL FILL (Qaf) " SAND (SP), red-brown to brown, medium dense to dense, fine-grained, with gravel in upper 2 ft.					
15.0		1	19							
	10	2	44							
5.0					" DUNE SAND (Qd) " SAND (SP), light brown to brown, dense to very dense, fine-grained					
		3	31							
	20	4	71		Very dense and saturated below 21 ft.					
-5.0					(3.0% passing No. 200 sieve)	103	22			SA
		5	89		" COLMA FORMATION (Qc) " SAND (SP), brown, very dense, medium to coarse-grained					
	30	6	110/8"		" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), brown, very dense, fine to medium-grained	90	29	36	30	
-15.0		7	12		" COLMA FORMATION (Qc) "					

LOG OF DRILL HOLE

AGS

Great Highway Seawall LOGGED BY: EII
..E NO.: DH-21 CHECKED BY: CS
METHOD: Rotary Wash DRILLING DATE: 5/16-17/85

REFERENCE EL.: 21.0 ft.
DATUM: SFCD

SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
			"COLMA FORMATION (Qc)" CLAYEY SAND (SC), dark gray, medium dense (30.5% passing No. 200 sieve)					
3	81		"COLMA FORMATION (Qc)" CLAYEY SAND (SC), orange-brown, very dense (14.9% passing No. 200 sieve)	113	18			SA
9	98/11"							
10	109		"COLMA FORMATION (Qc)" SLIGHTLY SILTY SAND (SP-SM), gray-brown, very dense, fine to medium-grained	107	22			
			"COLMA FORMATION (Qc)" CLAYEY SAND (SC), orange-brown, very dense					
11	106/9"							
			Bottom of boring at 63½ ft. below the ground surface at approximately elevation-42½ ft. (SFCD)					

..2 OF 2

PLATE A- 1.43

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EII
DRILL HOLE NO.: DH-22(P) CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/29-30/85

REFERENCE EL.: 20.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0				"ARTIFICIAL FILL (Qaf)" SAND (SP), brown, medium dense, fine-grained with some gravel @ 0-2 ft.					
15.5		1	19							
	10	2	11							
						100	6			
5.5		3	11							
	20	4	64		"DUNE SAND (Qd)" SAND (SP), brown, very dense, fine-grained (2.4% passing No. 200 sieve)					SA
					Saturated below 24 ft. 6-7-85	102	20			
-4.5		5	100/11"							
	30	6	85/11"		"COLMA FORMATION (Qc)" SAND (SP), red-brown, very dense, medium-grained with some gravel					
		7	9		"COLMA FORMATION (Qc)" CLAYEY SAND (SC), gray-brown, loose to very dense, fine-grained (44.1% passing No. 200 sieve)	114	17			SA
-14.5										

SHEET 1 OF 2

PLATE A- 1.44

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-22(P)
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 5/29-30/85
REFERENCE EL.: 20.5 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35			" COLMA FORMATION (Qc) " CLAYEY SAND (SC), gray-brown, loose to very dense, fine-grained. Grading less clayey at 37 ft.					
-19.5		8	71/11"	(27.1% passing No. 200 sieve)					SA
		9	112/11"	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), red-brown, very dense, fine-grained (6.4% passing No. 200 sieve)	112	17			SA
	45								
-29.5									
	55								
		10	82						
-39.5				Bottom of boring at 59½ ft. below the ground surface at approximately elevation-39 ft. (SFCD)					
	65			Piezometer Installed in boring					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-23
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 5/17/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0			" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, dense to very dense, fine-grained Baserock @ 0-1 ft.					
16.0									
		1	31						
	10			Grading slightly siltier @ 9 ft. (4.7% passing No. 200 sieve)					
		2	93						SA
6.0				" DUNE SAND (Qd) " SAND (SP), light brown to brown, dense to very dense, fine-grained (2.1% passing No. 200 sieve)					
		3	37		105	17			SA
	20			Saturated at 21 ft. Very dense below 21 ft.					
		4	76						
-4.0									
		5	102		112	19			
	30			" COLMA FORMATION (Qc) " SILTY-CLAYEY SAND (SM-SC) dark brown, medium dense, fine-grained (46.5% passing No. 200 sieve)					
		6	24				17	11	SA
-14.0									

24

LOG OF DRILL HOLE

AGS

[...]CT: Great Highway Seawall
HOLE NO.: DH-23
[...]NG METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/17/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	7	76		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), yellow-brown, dense to very dense, fine to medium-grained	109	19			
	8	41			111	19			
				Bottom of boring at 45½ ft. below the ground surface at approximately elevation-24½ ft. (SFCD)					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-24
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 6/3/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0					" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, medium dense, fine-grained					
16.0			1	18							
	10		2	25							
						" DUNE SAND (Qd) " SAND (SP), light brown to brown, medium dense to very dense, fine-grained	100	6			
6.0			3	20							
	20		4	56		Very dense and saturated below 20 ft.					
							103	17			
-4.0			5	97/10"							
											SA
	30		6	93/10"		(4.7% passing No. 200 sieve)					
-14.0			7	37		" COLMA FORMATION (Qc) " SANDY CLAY (CL), dark gray, very stiff	122	13			SA

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-24 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 6/3/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35			(54.9% passing No. 200 sieve)					
		8	69	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), yellow-brown to red-brown, very dense, fine-grained (24.9% passing No. 200 sieve)					SA
-19.0									
				Grading less clayey @ 42 ft.					
	45								
				Slightly clayey @ 46 ft.					
		9	118/11"		113	18			
-29.0									
	55								
		10							
-39.0									
				Grading more clayey @ 62 ft.					
	65								
		11	82/10"						
-49.0									

SHEET . OF .   PLATE A- 1.49

24

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-24 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 6/3/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	70								
				" COLMA FORMATION (Qc) " SAND (SP), brown, very dense, fine-grained					
-54.0									
		12	110/9"		112	18			
				Bottom of boring at 77½ ft. below the ground surface at approximately elevation-56½ ft. (SFCD)					
	80								

SHEET . OF .   PLATE A- 1.50

LOG OF DRILL HOLE

AGS

ECT: Great Highway Seawall
L HOLE NO.: DH-25
LING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/20/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
0	1		" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, medium dense, fine-grained					
	2	19						
10	3	42	" DUNE SAND (Qd) " SAND (SP), brown, dense to very dense, medium to fine-grained (1.9% passing No. 200 sieve)					SA
0	4	45		106	17			
20	5	90 / 11"	Very dense and saturated below 20 ft. Some fragments of partially decomposed wood @ 20 ft. (4.5% passing No. 200 sieve)					SA
.0	6	109	Thin gravel lens @ 29'	110	20			
30	7	30	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), dark gray, medium dense (32.8% passing No. 200 sieve)					SA
14.0	8	24	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), orange-brown, medium dense to very dense (13.5% passing No. 200 sieve)	114	17			SA

HEET 1 OF 2

PLATE A- 1.51

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
DRILL HOLE NO.: DH-25
DRILLING METHOD: Rotary Wash
LOGGED BY: EH
CHECKED BY: CS
DRILLING DATE: 5/20/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35			" COLMA FORMATION (Qc) " CLAYEY SAND (SC), orange-brown, medium dense to very dense					
-19.0		9	78	Very dense @ 40 ft.					
				Bottom of boring at 40½ ft. below the ground surface at approximately elevation-19.5 ft. (SFCD)					
	45								

SHEET 2 OF 2

PLATE A- 1.52

25

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-26
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 5/29/85
REFERENCE EL.: 20.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0	1		" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, loose to medium dense, fine-grained with some gravel @ 0-2 ft.					
15.0		2	10						
	10	3	24	(1.9% passing No. 200 sieve)					SA
5.0		4	30	" DUNE SAND (Qd) " SAND (SP), light brown, dense, fine-grained	95	3			
	20	5		Saturated below 20 ft.					
-5.0		6	98	" COLMA FORMATION (Qc) " SAND (SP), brown, very dense, fine to medium-grained Medium to coarse-grained at 24-25½ ft. (2.2% passing No. 200 sieve)					SA
	30	7	90/10"	(3.9% passing No. 200 sieve)					SA
-15.0		8	117/11"	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), red-brown to yellow-brown, very dense, fine-grained	116	17			

24

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-26
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 5/29/85
REFERENCE EL.: 20.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35			" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), red-brown to yellow-brown, very dense, fine-grained					
-20.0									
	45	9	80/6"	(5.2% passing No. 200 sieve)					SA
-30.0									
	55	10	76		101	25			
-40.0				Bottom of boring at 59½ ft. below the ground surface at approximately elevation-39½ ft. (SFCD)					
	65								

LOG OF DRILL HOLE

AGS

OJECT: Great Highway Seawall LOGGED BY: EH
ILL HOLE NO.: DH-27 (P) CHECKED BY: CS
ILLING METHOD: Rotary Wash DRILLING DATE: 5/20/85

REFERENCE EL.: 20.5 ft.
DATUM: SFCD

(FEET) DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
0			" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, medium dense, fine-grained					
5.5	1	25						
10	2	25						
			" DUNE SAND (Qd) " SAND (SP), light brown to brown, medium dense to dense, fine-grained	105	18			
5.5	3	20						
			Dense and saturated below 19 ft.					
20	4	36	6-7-85					
-4.5	5	47	Grading to fine to medium grained @ 24 ft. (2.4% passing No. 200 sieve)					SA
30	6	92/11"						
			" COLMA FORMATION (Qc) " CLAYEY SAND (SC), tan-brown to orange-brown, dense to very dense, fine to medium-grained (14.8% passing No. 200 sieve)	113	17			SA
	7	31						
-14.5								

SHEET 1 OF 2

PLATE A- 1.55

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-27 (P) CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/20/85

REFERENCE EL.: 20.5 ft.
DATUM: SFCD

ELEVATION (FEET) DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
35			" COLMA FORMATION (Qc) " CLAYEY SAND (SC), tan-brown to orange-brown, dense to very dense, fine to medium-grained					
-19.5	8	83	Very dense below 40 ft.	110	18			
45								
-29.5	9	100/9"						
55								
-39.5								
	10	68		107	22			
65			Bottom of boring at 64½ ft. below the ground surface at approximately elevation-44 ft. (SFCD)					
			Piezometer installed in boring					

SHEET 2 OF 2

PLATE A- 1.56

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-28(P)
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 6/6/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0			" ARTIFICIAL FILL (Qaf) " SAND (SP), light brown to brown, medium dense to dense, fine-grained					
16.0		1	14	Baserock at 0-1½ ft.					
	10	2	49						
6.0		3	6	" DUNE SAND (Qd) " SAND (SP), light brown to brown, loose to very dense, fine-grained	95	14			
	20	4	29	6-7-85 (2.5% passing No. 200 sieve)					SA
-4.0		5	74	Saturated below 25 ft.					
	30	6	92 9"						
-14.0				" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), brown, very dense, fine-grained					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall
LOGGED BY: EH
DRILL HOLE NO.: DH-28(P)
CHECKED BY: CS
DRILLING METHOD: Rotary Wash
DRILLING DATE: 6/6/85
REFERENCE EL.: 21.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35	7	86	" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), brown to red-brown, very dense, fine-grained (5.4% passing No. 200 sieve)	106	20			SA
-19.0									
	45	8		(1.8% passing No. 200 sieve)					SA P
-29.0									
	55								
		9	30	(5.5% passing No. 200 sieve)					SA
-39.0				" COLMA FORMATION (Qc) " CLAY (OH), with organics, black, very stiff					
	65			" COLMA FORMATION (Qc) " SLIGHTLY SILTY SAND (SP-SM), gray-brown, very dense, fine to medium-grained					
		10	103 11"		120	15			
-49.0				Bottom of boring at 66½ ft. below the ground surface at approximately elevation-45½ ft. (SFCD) Piezometer installed in boring					

LOG OF DRILL HOLE

AGS

CT: Great Highway Seawall | LOGGED BY: EH | REFERENCE EL.: 20.5 ft.
HOLE NO.: DH-29 | CHECKED BY: CS | DATUM: SFCD
NG METHOD: Rotary Wash | DRILLING DATE: 5/21/85

SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	1			" ARTIFICIAL FILL (Qaf) " SAND (SP), red-brown to brown, medium dense, fine-grained Baserock @ 0-1 ft.					
	2	15							
	3	27		Trace of gravel @ 10 ft.					
	4	46		" DUNE SAND (Qd) " SAND (SP), brown, dense to very dense	109	15			
	5	68		Saturated below 19 ft. Trace of organics at 20 ft.					
	6	47		(3.5% passing No. 200 sieve)					SA
	7	50							
	8	20		" COLMA FORMATION (Qc) " SILTY SAND (SM), dark gray to red-brown, medium dense to dense, fine-grained Grading more clayey @ 31 ft. (32.9% passing No. 200 sieve)	121	14			SA

ET 1 OF 2

PLATE A- 1.60

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall | LOGGED BY: EH | REFERENCE EL.: 20.5 ft.
DRILL HOLE NO.: DH-29 | CHECKED BY: CS | DATUM: SFCD
DRILLING METHOD: Rotary Wash | DRILLING DATE: 5/21/85

ELEVATION (FEET)	DEPTH	SAMPLE	SAMPLE NO.	BLOW COUNTS/FT.	GRAPHIC LOG	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35										
-19.5			9	81		" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), orange-brown, very dense, fine to medium-grained					
	45					Bottom of boring at 45 ft. below the ground surface at approximately elevation-24½ ft. (SFCD)					

SHEET 2 OF 2

PLATE A- 1.60

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-31 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/21/85

REFERENCE EL.: 18.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	0			" ARTIFICIAL FILL (Qaf) " SAND (SP), red-brown, dense, fine-grained, with some gravel Baserock @ 0-1 ft.					
		1	45						
13.0				" DUNE SAND (Qd) " SAND (SP), brown, medium dense to dense, fine-grained (2.0% passing No. 200 sieve)					
		2	18						SA
	10								
		3	24						
3.0									
		4	46	Dense below 17 ft.					
	20								
				Saturated below 22 ft.					
		5	72	" COLMA FORMATION (Qc) " SAND (SP), red-brown, very dense, medium to coarse-grained	110	14			
-7.0									
		6	90/11"						
	30								
		7	103	" COLMA FORMATION (Qc) " SAND (SP), brown, very dense, fine-grained	110	18			
17.0				" COLMA FORMATION (Qc) "					

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-31 CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/21/85

REFERENCE EL.: 18.0 ft.
DATUM: SFCD

ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35			" COLMA FORMATION (Qc) " SILTY SAND (SM), dark gray to green-brown, dense to very dense, fine to medium-grained (25.6% passing No. 200 sieve) Grading less silty @ 40 ft.					
		8	35						SA
-22.0									
		9	102	(15.7% passing No. 200 sieve)	112	17			SA
	45								
		10	118/10"	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), yellow-brown, very dense, fine-grained	104	23			
-32.0									
	55								
		11							
-42.0				Bottom of boring at 57½ ft. below the ground surface at approximately elevation -39½ ft. (SFCD)					
	65								

30

LOG OF DRILL HOLE

AGS

CT: Great Highway Seawall LOGGED BY: EH
HOLE NO.: DH-32(P) CHECKED BY: CS
ING METHOD: Rotary Wash DRILLING DATE: 5/28-29/85
REFERENCE EL.: 13.0 ft.
DATUM: SFCD

DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
			" ARTIFICIAL FILL (Qaf) " SANDY CLAY (CL), red-brown, very stiff					
	1	45	" DUNE SAND (Qd) " SAND (SP), brown, medium dense to very dense, fine-grained					
	2	35						
	3	21	Saturated below 12 ft. 6-7-85	98	14			
	4	74	Color change to yellow-brown @ 18 ft. (2.9% passing No. 200 sieve)					SA
0								
	5	35	" COLMA FORMATION (Qc) " SAND (SP), tan-brown, dense, fine to medium-grained (4.0% passing No. 200 sieve)	109	19			SA
.0								
30	6	81/11"	" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), brown to yellow-brown, very dense, fine-grained					
	7	73		106	20			
.0								

EET 1 OF 2

PLATE A- 1.63

LOG OF DRILL HOLE

AGS

PROJECT: Great Highway Seawall LOGGED BY: EH
DRILL HOLE NO.: DH-32(P) CHECKED BY: CS
DRILLING METHOD: Rotary Wash DRILLING DATE: 5/28-29/85
REFERENCE EL.: 13.0 ft.
DATUM: SFCD

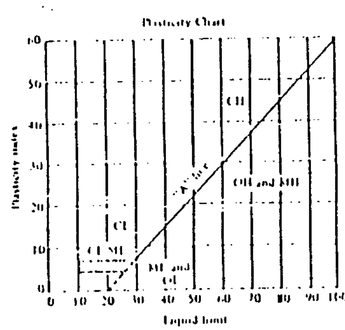
ELEVATION (FEET)	DEPTH	SAMPLE NO.	BLOW COUNTS/FT.	GEOTECHNICAL DESCRIPTION AND CLASSIFICATION	DRY DENSITY (PCF)	MOISTURE CONTENT (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	ADDITIONAL TESTS
	35			" COLMA FORMATION (Qc) " SLIGHTLY CLAYEY SAND (SP-SC), yellow-brown, very dense, fine-grained					
		8	97/9"						
-27.0									
		9	16	" COLMA FORMATION (Qc) " CLAY (OH), with some organics, black, very stiff	82	36	139	106	
	45								
-37.0		10	40	" COLMA FORMATION (Qc) " SAND (SP), tan-brown, dense, fine-grained	108	24			SA
	55	11	83/10"	" COLMA FORMATION (Qc) " CLAYEY SAND (SC), green-brown, very dense, fine-grained					
-47.0				Bottom of boring at 60 ft. below the ground surface at approximately elevation-47 ft. (SFCD)					
	65			Piezometer installed in boring					

SHEET 2 OF 2

31

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D 2487)

Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 per cent GW, GP, SW, SP; More than 12 per cent GM, GC, SM, SC; 5 to 12 per cent Borderline cases requiring dual symbols	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM (d, u)	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits below "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM (d, u)	Silty sands, sand-silt mixtures		Atterberg limits above "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils (More than half material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity, organic silts			
Highly organic soils			Pt	Peat and other highly organic soils			



AGS

SOIL CLASSIFICATION SUBDIVISIONS

Division of GM and SM groups may be subdivided into d and u for roads and airfields. Suffix d is used when liquid limit is 28 or less and plastic index is 6 or less whereas suffix u is used when liquid limit is greater than 28.

SAMPLE TYPES

Bulk Sample
Pushed Shelby Tube
Pitcher Barrel
Standard Penetration
Modified California

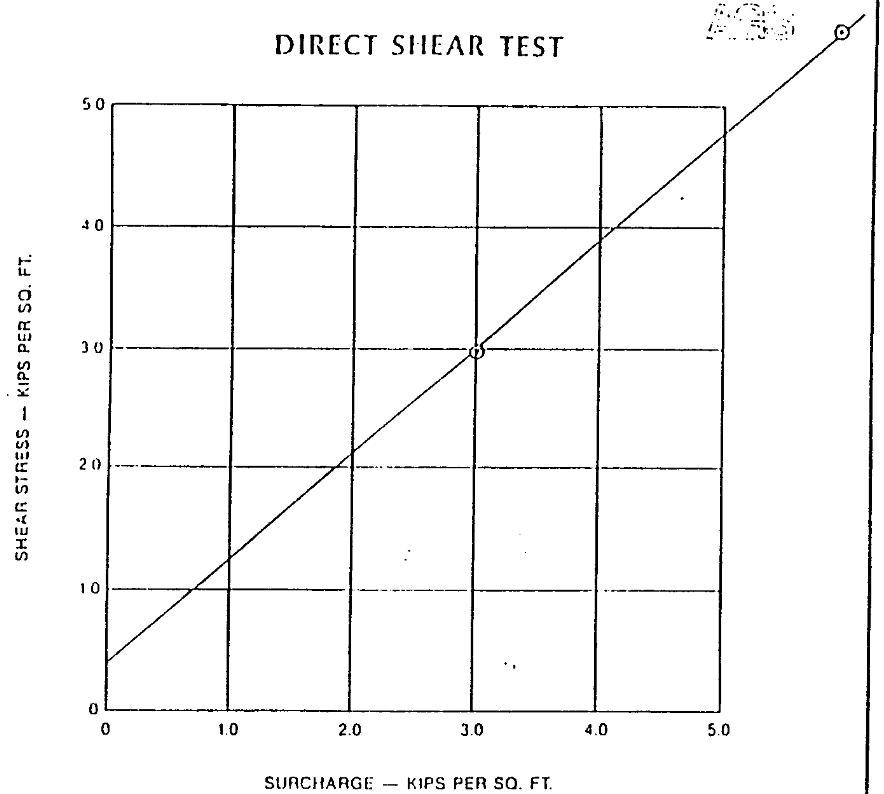
BLOW COUNT

The number of blows required to drive the sampler the last 12 inches of an 18 inch drive. The notation 100/9 indicates 9 inches of penetration were achieved in 100 blows.

ADDITIONAL TESTS

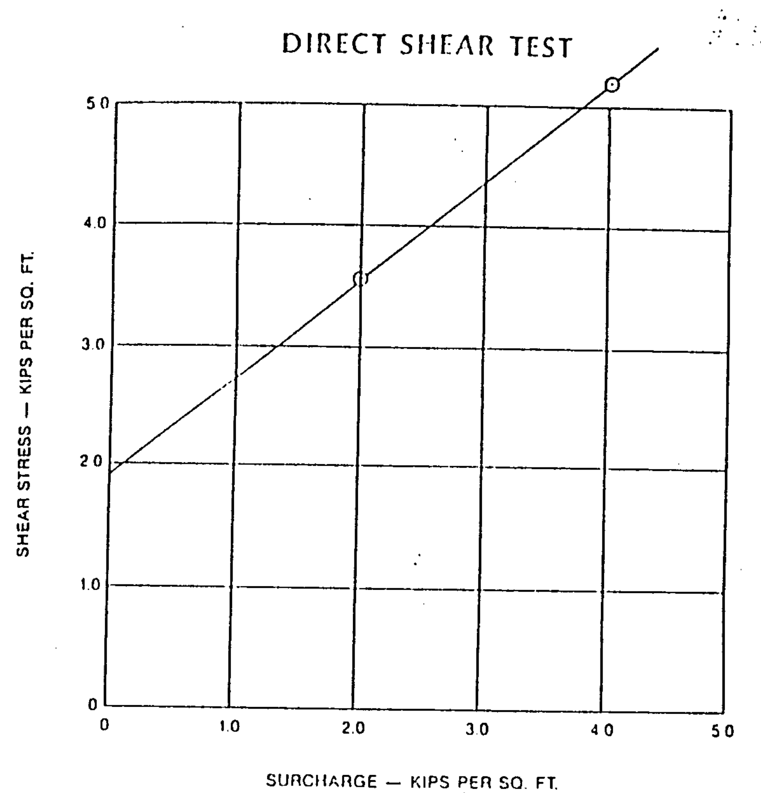
UC : Unconfined Compression	DS : Direct Shear
TD : Drained Triaxial Compression	PM : Permeability
TU : Undrained Traxial Compression	EX : Expansion
GS : Grain Size Distribution	SW : Swell
SP : Specific Gravity	PS : Resistivity
CP : Compaction	CBR : California Bearing Ratio
CN : Consolidation	RV : R-Value
TV : Torvane Shear	PP : Pocket Penetrometer

PLATE A 2 UNIFIED SOIL CLASSIFICATION & LEGEND TO DRILL HOLE LOGS



DESCRIPTION OF SAMPLE	CLAYEY SAND (SC), yellow brown, fine to medium-grained		
BORING: DH 17	DEPTH: 43 ft.	ELEVATION: -22.0 ft. (SFCD)	
APPARENT ANGLE OF INTERNAL FRICTION (Ø) 40.5		APPARENT COHESION (C) 0.40 KSF	
NATURAL VOID RATIO		EXISTING OVERBURDEN STRESS (KSF)	3.92
DRY DENSITY (PCF)	101	SHEAR RATE (IN/MIN)	.00074
NATURAL MOISTURE CONTENT %	18	PEAK STRENGTH/RESIDUAL STRENGTH	

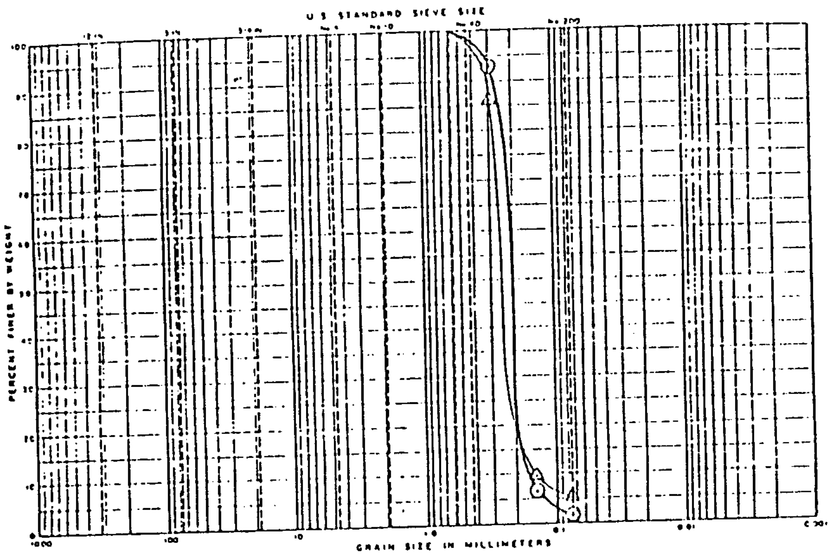
JOB NO. SF41109 DATE: 6/85 PLATE: A-3.1



DESCRIPTION OF SAMPLE	CLAYEY SAND (SC), gray-brown, fine-grained		
BORING: DH-11	DEPTH: 52 ft.	ELEVATION: -31.5 ft. (SFCD)	
APPARENT ANGLE OF INTERNAL FRICTION (Ø) 40		APPARENT COHESION (C) 1.90 KSF	
NATURAL VOID RATIO		EXISTING OVERBURDEN STRESS (KSF)	4.59
DRY DENSITY (PCF)	98	SHEAR RATE (IN/MIN)	
NATURAL MOISTURE CONTENT %	26	PEAK STRENGTH/RESIDUAL STRENGTH	

JOB NO. SF41109 DATE: 6/85 PLATE A-3.2

AGS

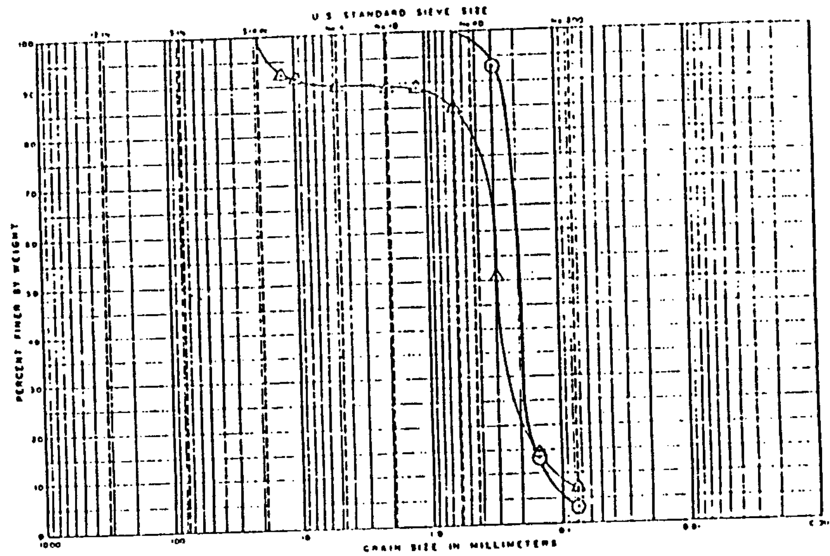


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

LEGEND	—⊙—	—▽—	
BORING NUMBER	DH-3	DH-3	
DEPTH (FEET)	15	30	
SOIL DESCRIPTION	SP	SP	
EFFECTIVE SIZE, D_{10}	0.17 mm	0.15 mm	
COEFFICIENT OF UNIFORMITY D_{60}/D_{10}	1.2	1.7	
COEFFICIENT OF CURVATURE	1.1	1.4	

AGS



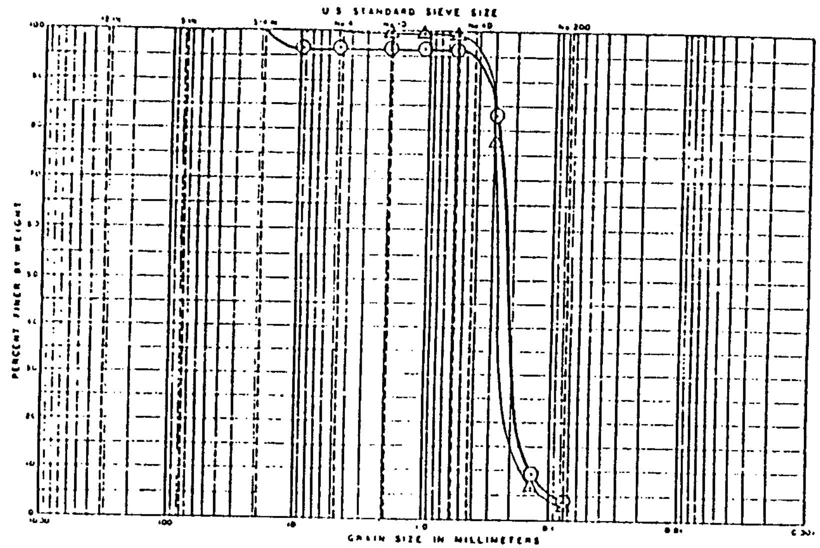
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

LEGEND	—⊙—	—△—	
BORING NUMBER	DH-4	DH-4	
DEPTH (FEET)	20	32	
SOIL DESCRIPTION	SP	SP	
EFFECTIVE SIZE, D_{10}	0.14 mm	0.12 mm	
COEFFICIENT OF UNIFORMITY D_{60}/D_{10}	1.4	2.5	
COEFFICIENT OF CURVATURE	1.3	1.9	

GRADATION TEST DATA

AGS

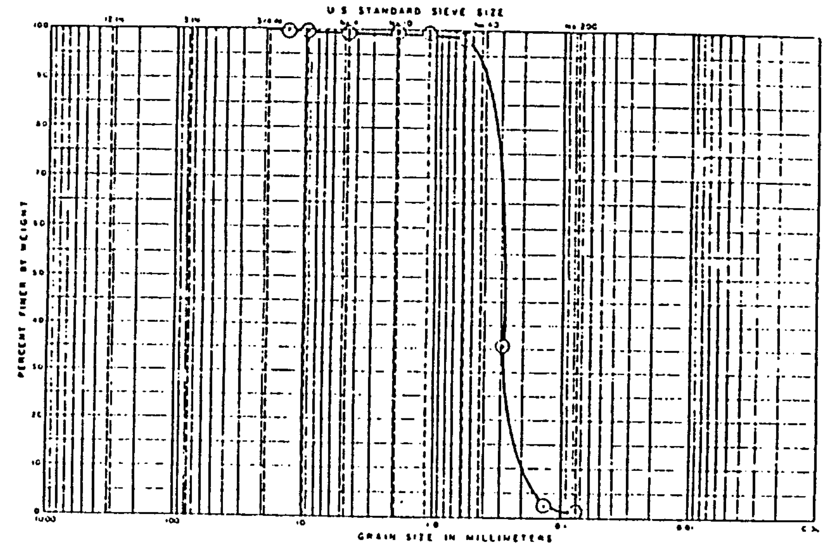


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

(U N I F I E D S O I L C L A S S I F I C A T I O N S Y S T E M)

LEGEND	—⊙—	—△—	
BORING NUMBER	DH-13	DH-19	
DEPTH (FEET)	30	5	
SOIL DESCRIPTION	SP	SP	
EFFECTIVE SIZE, D_{10}	0.15 mm	0.17 mm	
COEFFICIENT OF UNIFORMITY D_{60}/D_{10}	1.5	1.6	
COEFFICIENT OF CURVATURE	1.2	1.4	

AGS

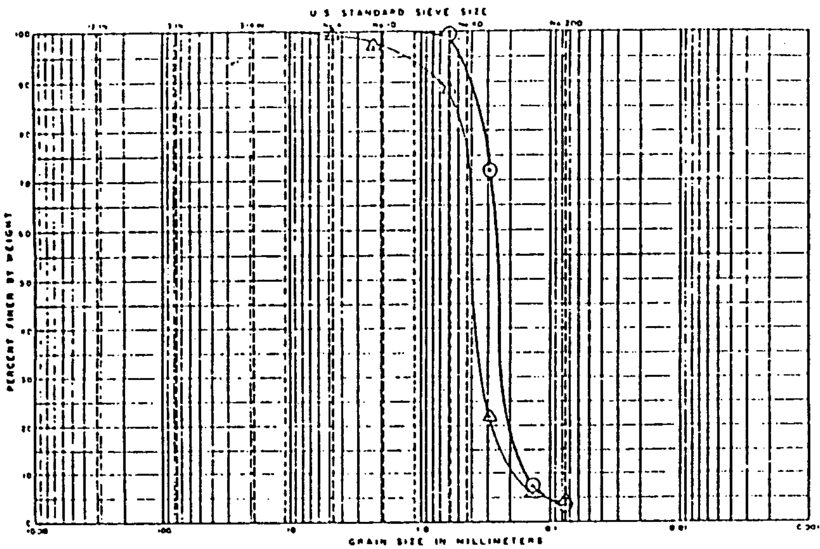


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

(U N I F I E D S O I L C L A S S I F I C A T I O N S Y S T E M)

LEGEND	—⊙—		
BORING NUMBER	DH-14		
DEPTH (FEET)	34		
SOIL DESCRIPTION	SP		
EFFECTIVE SIZE, D_{10}	0.20 mm		
COEFFICIENT OF UNIFORMITY D_{60}/D_{10}	1.5		
COEFFICIENT OF CURVATURE	1.4		

AGS

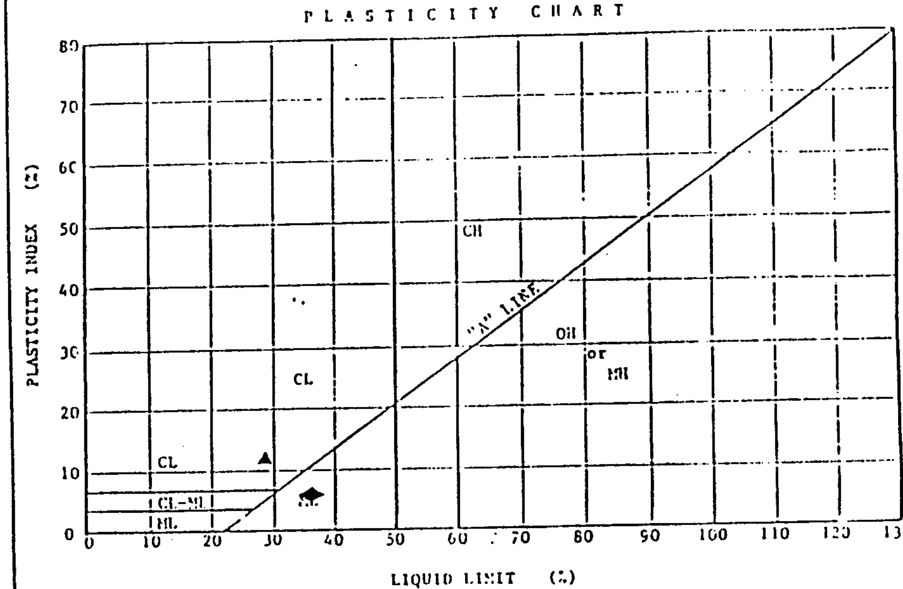


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

LEGEND	—○—	—△—	
BORING NUMBER	DH-29	DH-32	
DEPTH (FEET)	24	23	
SOIL DESCRIPTION	SP	SP	
EFFECTIVE SIZE, D_{10}	0.16 mm	0.19 mm	
COEFFICIENT OF UNIFORMITY D_{60}/D_{10}	1.7	2.1	
COEFFICIENT OF CURVATURE	1.3	1.5	

PLASTICITY CHART



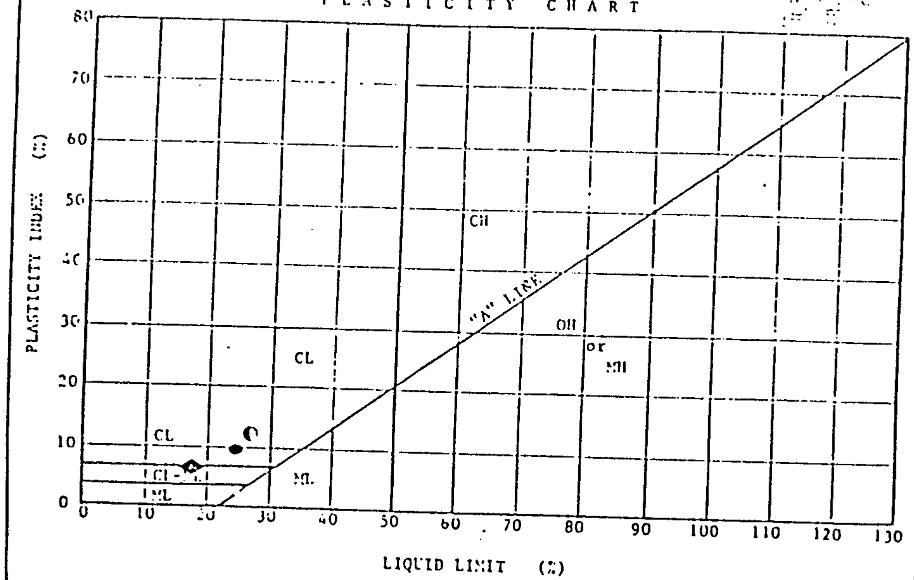
PLASTICITY DATA

KEY SYMBOL	SAMPLE NUMBER	DEPTH (ft)	NATURAL WATER CONTENT W (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	U.S.C.S.
▲	14-9	47	—	16.35	28.29	12	CL
●	32-9	42	—	105.65	139.04	33	OH/MH
◆	20-7	34	—	29.93	36.04	6	ML

ATTERBERG LIMITS TEST RESULTS

JOB NO. SF41104 DATE: 6/85 PLATE - A.5.1

PLASTICITY CHART



PLASTICITY DATA

KEY SYMBOL	SAMPLE NUMBER	DEPTH (ft)	NATURAL WATER CONTENT W (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTI-CITY INDEX (%)	U.S.C.S.
●	15-8	35	—	14.74	24.02	9	CL
◐	15-9	40	—	14.11	26.27	12	CL
◆	23-6	31	—	11.30	17.43	6	CL/ML

ATTERBERG LIMITS TEST RESULTS

JOB NO. SF41104 DATE: 6/85 PLATE - A-5.2

137

0 0 1

APPENDIX - E

COST ANALYSIS

OCEAN BEACH
STORM DAMAGE REDUCTION
FEASIBILITY STUDY
CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

OCEAN BEACH STUDY
BASIS OF COST

PROJECT DESCRIPTION: The project consists of refurbishing or mitigating sand lost annually from Ocean Beach, San Francisco.

ALTERNATIVES COST SUMMARY:

1. Annually Hopper Dredge Offshore and Pipe to Beach/Dunes:

Mob/Demob = $137,500
Dredge 10,000 cy/year = $ 58,800

TOTAL ANNUAL COST = $196,300 (See Attachment A)

2. Annually Haul Sand from Commercial Source:

Haul/Place 10,000 cy/year = $417,000

TOTAL ANNUAL COST = $417,000 (See Attachment B)

3. Construct 2,680 LF Taraval Type Wall:

Total Cost = $11,038,000

AVG 50-YEAR ANNUAL COST = $1,010,000 (See Attachment C)

ASSUMPTIONS:

1. Plant and equipment costs are from the U.S. Army Corps of Engineers 1992 Unit Price Book Database for Region VII, Escalated to June 1994. Labor costs are from the 1994 State of California wage rate determination sheets. The estimate assumes that the Contractor will be working 12 hours per day, 6 days per week. Land acquisition cost and site preparation costs were not developed. Costs shown for the Taraval Wall have been escalated to 1995.

2. All costs are preliminary and include a 25% contingency.

3. For the dredging alternative, a medium-sized dredge was assumed to remove 10,000 cubic yards per year @ $5.88/CY. Larger quantities will result in a lower unit cost.

4. For the hauling scenario, an average unit cost was used based on quotes from 5 suppliers for a 10,000 CY quantity. Larger quantities will result in a lower unit cost.

5. Costs for the Taraval Type Wall Alternative were based on unit costs obtained from a previous City/County of San Francisco project, scaled to 2,680 LF and escalated to 1995.

****

T. TITLE PAGE FOR PLANNING ESTIMATE.

****

Filename: OCEANB1.WK3

BID ITEM: 2

PROJECT: OCEAN BEACH NOURISHMENT

LOCATION: SAN FRANCISCO COUNTY,CA

INVIT NO: DACW07-94-B-0000

ESTIMATOR: Ed Gonzales

DESCRIPTION OF WORK:

--> WORK CONSISTS OF MAINTENANCE DREDGING OF APPROXIMATELY 10,000 CUBIC YARDS

--> OF SAND MATERIALS ALONG OCEAN BEACH AT SAN FRANCISCO TO REFURBISH THE DEPLETIN

--> SAND AT THE OCEAN BEACH. THE SAND WILL BE DREDGED AND PUMP ON TO THE BEACH,

--> USING THE HOPPER DREDGE. THE ESTIMATED MOUNT IS ONLY FOR UNIT PRICE

--> COMPUTATION.

-->

-->

Estimated By: Ed Gonzales 22 Sep 94

CHECKLIST FOR INPUT DATA.	UNIT $.	$5.88 /CY	
Planning Est. 22 Sep 94	TOTAL..	$58,800 JOB COST	
	TIME...	0.07 MONTHS	

PG 1 OF 14: PROJECT TITLES

PROJECT -	OCEAN BEACH NOURISHMENT
LOCATION -	SAN FRANCISCO COUNTY,CA
INVIT # -	DACW07-94-B-0000
BID ITEM # -	2
FILENAME -	OCEANB1.WK3
EST -	Ed Gonzales
MIDPT DATE -	Oct-95
DESCRIPTION ENTERED-	YES

PG 13 OF 14: MARKUPS USED

O.H.	15%
PROFIT	8%
BOND	1.000%

PG 2 OF 14: EXCAVATION QTY'S

DREDGING AREA -	23,994	sf
REQ'D EXCAVATION -	10,000	cyds
% MUD -	0%	
% SAND -	100%	
% GRAVEL -	0%	
PAY OVERDEPTH -	0	cyds
O.D. NOT DREDGED -	0	cyds
OVERDIG FOOTAGE -	0.00	ft
NONPAY YARDAGE -	0	cyds
GROSS YARDAGE -	10,000	cyds

PG 3 OF 14: LOCAL AREA FACTORS

FUEL COST -	$1.01	/gal
CFC RATE -	5.200%	
USE MONTHS / YEAR -	9	mo/yr
MARINE INSUR -	1.5%	
TAXES -	1.0%	
PROVISIONS & SUPP -	$15	/man

PG 4 OF 14: DREDGE SELECTION (ALT-D)

DREDGE: GENERIC MED.

LOADS PER DAY -	1.98	
CYCLE TIME -	399	min/load

PG'S 5-7 OF 14: PRODUCTION WORKSHEET

HOPPER CAPACITY -	3,800	cyds	DUMP/CONNECT TIME -	25	min
EFF. HOPPER CAP. -	2,280	cyds	JET PUMP AVAIL? -	YES	
AVAIL DREDGING RATE -	2,100	cy/hr	TYPE OF DISPOSAL -	PUMPOUT	
AVAIL. DRAGHEADS -	2	ea	PUMPING RATE -	500	cy/hr
ACT. DRAGHDS USED -	2	ea	TRVL SPD TO DREDG -	4.0	mph
DRDGE RATE USED -	2,100	cy/hr	MAX TRVL SPD LIGHT -	12.7	mph
TURNS/CYCLE -	1	ea	EFFECTIVE TIME -	55.0%	
MIN. PER TURN -	8	min	OPER WORK DAYS/MO -	30.42	days
DISPOSAL DIST -	1	mi	ADD. CLEANUP TIME -	0%	
TRVL SPD TO DISP -	5.0	mph	SPECIAL COST -	$0	/mo
MAX TRVL SPD LOADED -	11.5	mph	SPECIAL COST -	$0	/job

PG'S 8-9 OF 14: PLANT OWN. & OPER.

DREDGE	$318,681
PROPULSION TUG	self prop
SURVEY VESSEL	$0
BOOSTER	$0
CRANE BARGE	$0
TENDER TUG	$0
SHORE EQUIP	$0

PG 14 OF 14: DREDGE OPER. ADJ. FAC.

PUMP LOAD FACTOR	50%
RPR & MAINT. ADJ	1.00
JET PUMP % USAGE	100%

PG'S 10-12 OF 14: LABOR, FEB 94

OVERTIME % -	35.57%	
VACATION/HOLIDAY % -	0.00%	
TAX & INSUR % -	30.75%	
FRINGE BENEFITS -	$9.63	/hr
DREDGE CREW:		
SUGG. CREW SIZE -	14	ea
USED CREW SIZE -	14	ea
SHORE CREW:		
USED CREW SIZE -	3	ea
GOVERNMENT PERSON -	3	ea
FRE. PD TRAVEL -	28	days
RT TRAVEL COST -	$0	

BID ITEM: #2 A. EXCAVATION QUANTITIES

Filename: OCEANB1.WK3

1. EXCAVATION

A. Required	10,000	c.y.	Dredging Area = 23,994 sf
B. Pay Overdepth	0	c.y.	
C. Max. Pay Yardage	10,000	c.y.	(Yardage Used As Basis For Estimate)
D. O.D. Not Dredged	0	c.y.	Avg remaining depth of overdepth. = 0.0 ft.
E. Net Pay Yardage	10,000	c.y.	(Yardage Used To Figure Unit Price Per C.Y.)
F. Non-Pay Yardage	0	c.y.	Avg depth of Non-Pay excavation. = 0.0 ft.
G. Gross Yardage	10,000	c.y.	(Yardage Used To Figure Production Time & Cost)

2. PUMPOUT QUANITITY

A. Gross Yardage 10,000 c.y.

3. SUMMARY OF ADJUSTED DREDGE & PUMPOUT QUANTITIES.

TYPE	% DREDGED	TOTAL DREDGE CYDS	% PUMPOUT	TOTAL PUMPOUT CYDS
Mud:	0%	0	100%	0
Sand:	100%	10,000	100%	10,000
Gravel:	0%	0	100%	0
				10,000

Estimated By: Ed Gonzales 22 Sep 94

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BID ITEM: #2 B. PRODUCTION WORK SHEET
CYCLE TIME

****

Filename: OCEANB1.WK3

CYCLE TIME

1. Dredge Used:

A. Name of Dredge. 3800 CYD HOPPER DREDGE

B. Effective Dredge Hopper Cap. 2,280 cy

2. Time Per Average Load Cycle:

		REMARKS
A. Dredging	65 min	(2,280 cy / 2,100 cy/hr) x 60 min/hr.
B. Turning	8 min	1 turns at 8 minutes per turn.
C. To Disposal Or Mooring	12 min	(1.0 miles / 5.0 mph) x 60 min/hr.
D. Dumping Or Connect To Pipeline	25 min	
E. Pumpout Through Pipeline	274 min	(2,280 cy / 500 cy/hr) x 60 min/hr.
F. From Disposal Or Mooring	15 min	(1 miles / 4 mph) x 60 min/hr.

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3. Subtotal 399 min/load

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Estimated By: Ed Gonzales 22 Sep 94

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BID ITEM: #2 C. PRODUCTION WORK SHEET

DREDGING TIME

****

Filename: OCEANB1.WK3

DREDGING TIME				REMARKS
1 Available Minutes Per Dredging Day		1,440	min/day	(60 Min/Hr x 24 Hrs/Day)
2 Percent Effective Time	x	55%		
3 Daily Effective Time	=	792	min/wday	
4 Total Cycle Time	/	399	min/load	
5 Number Of Loads Per Day	=	1.98	loads/wday	
6 Cubic Yards Per Load	x	2,280	cy/load	
7 Operating Work Days Per Month	x	30.42	wdays/mo	
8 Gross Cubic Yards Per Month	=	137,328	cy/mo	
9 Gross Cubic Yards		10,000	cy (gross)	
10 Gross Cubic Yards Per Month	/	137,328	cy/mo	
11 Dredge Time	=	0.07	months	
12 Clean Up	+	0.00	months	0% Additional Dredging

13 Total Dredge Time		0.07	months

Effective + Non-Effective = (0.07 months x 24 hrs/day x 30.42 days/month)

= 51 hrs

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Estimated By: Ed Gonzales 22 Sep 94

D. MONTHLY PLANT OWNERSHIP & LABOR COST SUMMARY

BID ITEM: #2

EXCAVATION

Filename: OCEANB1.WK3

PLANT OWNERSHIP & OPERATING

1 Equipment 3800 CYD HOPPER DREDGE

2 Plant Ownership & Operating Expense			REMARKS
A. Hopper Dredge....>	$318,681	/mo	See "Dredge Rate" in Backup.
Propulsion Tug...>	self prop.	/mo	
B. Survey Vessel....>	$0	/mo	
C. Booster..........>	$0	/mo	
D. Crane Barge......>	$0	/mo	
E. Tender Tug.......>	$0	/mo	
F. Other Marine.....>	$0	/mo	
G. Shore Equip......>	$0	/mo	
3 INTEREST ON INVESTMENT on Plant........>	$37,612	/mo	
4 Labor Expense.......>	$313,181	/mo	See "Labor Rates" Attached
5 Travel Expense......>	$0	/mo	(30.42 dys/mo / 28 dys x $0 rt x 14 ea)
6 TOTAL MONTHLY COST	$669,474	/mo	

Estimated By: Ed Gonzales 22 Sep 94

BID ITEM: #2 E. EXCAVATION COSTS

Filename: OCEANB1.WK3

EXCAVATING COST				REMARKS
1 SubTotal Monthly Cost	=	$669,474	/mo	
Special Monthly Cost	=	$0	/mo	-
Total Monthly Cost	=	$669,474	/mo	
2 Dredge Time	x	0.07	months	
Subtotal...........	=	$46,863		
3 Special Lump Sum Costs	+	$0		-
4 Total Direct Costs	=	$46,863		
5 Contractors O.H. @ 15.0%		$7,029		
6 Subtotal...........	=	$53,892		
7 Profit @ 8.0%	=	$4,311		
8 Subtotal...........	=	$58,203		
9 CFC on Plant	=	$0		INTEREST ON INVEST. In Monthly Cost.
10 Subtotal...........	=	$58,203		
11 % Bond Cost @ 1.000%	=	$582		
12 Net Pay Yardage Cost	=	$58,785		
13 Net Pay Yardage	/	10,000	cy	
14 Unit Cost	=	$5.88	/cy	
15 Bid Quantity		10,000	cy	
16 Total Dredging Cost	=	$58,800		

Estimated By: Ed Gonzales 22 Sep 94

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F. MONTHLY PLANT OWNERSHIP & LABOR COST SUMMARY

MOBILIZATION & DEMOBILIZATION RATE CALCULATION SHEET

****

Filename: OCEANB1.WK3

PLANT OWNERSHIP & OPERATING

1 Equipment 3800 CYD HOPPER DREDGE

2 Plant Ownership & Operating Expense			REMARKS
A. Hopper Dredge....>	$299,486	/mo	See "Dredge Rate" in Backup.
Propulsion Tug...>	self prop.	/mo	
B. Survey Vessel....>	$0	/mo	
C. Booster..........>	$0	/mo	
D. Crane Barge......>	$0	/mo	
E. Tender Tug.......>	$0	/mo	
F. Other Marine.....>	$0	/mo	
G. Shore Equip......>	$0	/mo	
3 INTEREST ON INVESTMENT on Plant........>	$37,612	/mo	
4 Labor Expense.......>	$313,181	/mo	See "Labor Rates" Attached
5 Travel Expense......>	$0	/mo	(30.42 dys/mo / 28 dys x $0 rt x 14 ea)

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6 TOTAL MONTHLY COST	$650,279	/mo
DAYS / MONTH	30.42	dys/mo
DAILY COST..........	$21,377	/day

DAILY CFC........... INTEREST ON INVESTMENT INCLUDED IN ABOVE RATE.

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Estimated By: Ed Gonzales 22 Sep 94

Filename: OCEANB1.WK3

L. LABOR COSTS

Last Update... FEB 94

Overtime %	35.57%		Social Security Tax	7.65%
Vacation & Holiday %	0.00%		Employ. Liability Tax	6.90%
			Workers comp.	10.00%
COMPOSITE..............	35.57%		Unemployment tax	6.20%
			COMPOSITE..............	30.75%

EA	CREW	BASIC HOURLY WAGE	O.T. VACATION & HOLIDAY 35.57% AMOUNT	SUB-TOTAL AMOUNT	TAXES INSUR 30.75% AMOUNT	SUB-TOTAL AMOUNT	FRINGE BENEFITS $9.63 AMOUNT	HRLY COST AMOUNT	HOURS PER MONTH	MONTHLY COST
	Dredgecrew...									
1	Captain	30.55 +	10.87 =	41.42 +	12.74 =	54.16 +	9.63 =	63.79 x	365 =	$23,283
1	Chief Engineer	24.81 +	8.82 =	33.63 +	10.34 =	43.97 +	9.63 =	53.60 x	365 =	$19,564
1	Engineer	24.81 +	8.82 =	33.63 +	10.34 =	43.97 +	9.63 =	53.60 x	365 =	$19,564
1	Mate	24.81 +	8.82 =	33.63 +	10.34 =	43.97 +	9.63 =	53.60 x	365 =	$19,564
1	Dragtender/Deck	24.81 +	8.82 =	33.63 +	10.34 =	43.97 +	9.63 =	53.60 x	365 =	$19,564
2	Watch AB/Ord. S	24.81 +	8.82 =	33.63 +	10.34 =	43.97 +	9.63 =	53.60 x	730 =	$39,128
1	Cook	22.70 +	8.07 =	30.77 +	9.46 =	40.23 +	9.63 =	49.86 x	365 =	$18,199
1	Steward/Ast. En	17.70 +	6.30 =	24.00 +	7.38 =	31.38 +	9.63 =	41.01 x	365 =	$14,969
3	Seaman AB/Able	21.69 +	7.72 =	29.41 +	9.04 =	38.45 +	9.63 =	48.08 x	1095 =	$52,648
0	AB Wiper	11.04 +	3.93 =	14.97 +	4.60 =	19.57 +	9.63 =	29.20 x	0 =	$0
2	Launchman/Mate	21.69 +	7.72 =	29.41 +	9.04 =	38.45 +	9.63 =	48.08 x	730 =	$35,098
0	Oiler	15.02 +	5.34 =	20.36 +	6.26 =	26.62 +	9.63 =	36.25 x	0 =	$0
14	crew total								TOTAL MONTHLY LABOR COST =	$261,581
									CALC. CREW SIZE (FROM ABOVE) /	14
									AVERAGE MONTHLY LABOR COST/MAN =	$18,684
									CREW SIZE FOR DREDGE x	14
									TOTAL MONTHLY LABOR COST =	$261,581
	Shorecrew...									
1	Superintendent	23.87 +	8.49 =	32.36 +	9.95 =	42.31 +	9.63 =	51.94 x	365 =	$18,958
0	Dump Foreman	10.90 +	3.88 =	14.78 +	4.54 =	19.32 +	9.63 =	28.95 x	0 =	$0
0	Equip. Oper.	10.35 +	3.68 =	14.03 +	4.31 =	18.34 +	9.63 =	27.97 x	0 =	$0
0	Shoreman	8.47 +	3.01 =	11.48 +	3.53 =	15.01 +	9.63 =	24.64 x	0 =	$0
1	Project Enginee	23.87 +	8.49 =	32.36 +	9.95 =	42.31 +	9.63 =	51.94 x	365 =	$18,958
1	Office Manager	15.72 +	5.59 =	21.31 +	6.55 =	27.86 +	9.63 =	37.49 x	365 =	$13,684
0	????	0.00 +	0.00 =	0.00 +	0.00 =	0.00 +	9.63 =	9.63 x	0 =	$0
									TOTAL MONTHLY LABOR COST	$313,181

OWNERSHIP AND OPERATING EXPENSE RATES

MARINE EQUIPMENT

PROJECT: OCEAN BEACH NOURISHMENT
IFB No.: DACW07-94-B-0000
BID ITEM No.: 2
Filename: OCEANB1.WK3

PLANT PHYSICAL DATA: (FROM DREDGE DATA BASE)

Plant Description - - - -> 3800 CYD HOPPER DREDGE

Type Of Plant - - - - - - ->	HOPPER	
Total Installed Horsepower ->	8,000	hp
Hopper Capacity (CY) - - - ->	3,800	cy
# Of Dragheads Available - ->	2	ea
Fuel Type - - - - - - - - ->	DIESEL	
Is A Rental Tug Needed ? - ->	NO	
Crew Size (CS) - - - - - - ->	14	ea
Min. Digging Depth - - - - ->	14	ft
Max. Digging Depth - - - - ->	70	ft
Speed Loaded (Mph) - - - - ->	11.5	mph
Speed Light (Mph) - - - - ->	12.7	mph
Max. Load - - - - - - - - ->	2,500	cy
Draft Loaded - - - - - - - ->	19.4	ft
Jet Pump Available - - - - ->	YES	
Max. Pumpout Length - - - ->	NA	ft
Suction Pipe Diam. - - - - ->	27	inches
Discharge Pipe Diam. - - - ->	24	inches
Pumpout Pipe Diam. - - - - ->	24	inches

POWER REQUIREMENTS FOR FUEL CONSUMPTION FOR THE DREDGE:

	SUMMARY OF RATED HP (1)		TOTAL REQUIRED HP (2)
DESCRIPTION	ELECTRIC	DIESEL	DIESEL
Propulsion	0	3,500	3,500
Dredge Pump(s)	0	2,000	2,000
Jet Pump	0	565	565
Pumpout Pump(s)	0	2,000	2,000
Auxillary & Misc	1,080	600	1,935

(1). Rated hp is the output power of drive engines or motors or equivalent hp of other misc electrical loads.

(2). Total required hp is the rated bhp of engines when the type of power is diesel, or the rated bhp of generator engines providing the power when the type of power is electric.

OWNERSHIP AND CFC COSTS

HOPPER DREDGE OWNERSHIP AND CFC COST DATA Filename: OCEANB1.WK3

ACQUISITION COST (A):	$16,600,000
CAPITAL IMPROVEMENTS (I) @ 10% OF (A):	$1,660,000
(A + I)	$18,260,000
CFC (R):	5.200%
SALVAGE VALUE FACTOR (S):	10%
ECONOMIC LIFE (N):	20 yrs
YEAR COMMISSIONED :	1981
DATE AT MID PT OF WORK:	Oct-95
AGE IN YEARS (T):	14.3 yrs
USE MONTHS PER YEAR (UMPY):	9 months
MARINE INSURANCE (MI):	1.50%
TAXES (TA):	1.00%
LAYUP (LU):	$47,000 per layup month
YARD COST (Y):	$6,000 per month

CALCULATIONS

1. OWNERSHIP

DEPRECIATION = (A+I)*[1-S]/N	= ($18260000) x [1 - 10%] / 20 =	$	821,700	/YR
MARINE INSURANCE = MI(A+I)	= 1.50% x ($18260000) =	$	273,900	/YR
TAXES = TA(A+I)	= 1.00% x ($18260000) =	$	182,600	/YR
LAYUP = (LU)(12-1-UMPY)	= ($47000) x (12-1-9) =	$	94,000	/YR
YARD = 12(Y)	= 12 x ($6000) =	$	72,000	/YR
TOTAL YEARLY OWNERSHIP:		$	1,444,200	/YR
MONTHLY OWNERSHIP: YRLY OWNERSHIP / UMPY = $1444200 / 9 USE MONTHS		= $	160,467	/MO
DAILY OWNERSHIP: MTHLY OWNERSHIP / DYS/MO = $160467 / 30.42 DYS/MO		= $	5,274	/DAY

2. COST OF FACILITIES CAPITAL (INTEREST ON INVESTMENT)

YEARLY CFC = (A+I)R[1-(T(1-S)/N)] = = ($18260000) x (5.200%) x [1-(14.3(1-10%)/20)] =	$	338,504	/YR
MONTHLY CFC = (YEARLY CFC/UMPY) = ($338504/9.0) =	$	37,612	/MO
DAILY CFC = (MONTHLY CFC/(DAYS/MONTH)) = ($37612/30.42) =	$	1,236	/DAY

OPERATING COSTS

Filename: OCEANB1.WK3

1. FUEL

a. At Dredge Site

FUEL USE CONSUMPTION SUMMARY

DESCRIPTION	DREDGING	TURNING, SAILING & DISPOSAL	PUMPOUT	TOTAL NON-EFFECTIVE TIME	TOTALS	JET @ 100% DREDGE TIME
CYCLE TIME IN MIN.	65	60	274	326	725	65
% OF TOTAL CYCLE TIME	9.0%	8.3%	37.8%	45.0%	100.0%	9.0%
FUEL CONSUMPTION IN GAL/HR						
Propulsion	7.5	12.2	0.0		19.7	
Pumps (2 dragheads used)	4.8	0.0	31.7		36.5	1.4
Auxillary & Misc.	2.8	2.1	9.5	11.3	25.7	
Subtotals:	15.1	14.3	41.2	11.3	81.9	1.4

AVERAGE HOURLY FUEL CONSUMPTION : 83.3 GAL/HR

HISTORICAL FUEL CONSUMPTION DATA NOT AVAILABLE OR NOT USED........

AVERAGE HOURLY FUEL COST @ $1.01 /GAL = $ 84.13 /HR

b. During Mob & Demob Operation. FUEL USE CONSUMPTION SUMMARY

DESCRIPTION	MOB & DEMOB
Propulsion = (Propulsion hp x Propulsion factor during sailing) =	147.0 GAL/HR
Aux. & Misc. = (Aux. & Misc. hp x Aux. & Misc. factor during sailing) =	25.2 "
TOTAL HOURLY FUEL CONSUMPTION DURING MOB & DEMOB:	172.2 GAL/HR
AVERAGE HOURLY FUEL COST @ $1.01 /GAL =	$ 173.92 /HR

2. LUBRICANTS

TOTAL INSTALLED POWER = 8,000 HP

HOURLY COST FOR LUBRICANTS, FROM TABLE B: $10.65 /HR
AVERAGE HOURLY COST FOR LUBRICANTS, x 55.0% (1) = $ 5.86 /HR

3. REPAIRS AND MAINTENANCE

TOTAL INSTALLED POWER = 8,000 HP

HOURLY REPAIRS & OVERHAULS $179.00
AVG. HOURLY COST FOR REPAIRS & MAINT. x 55.0% (1) = $ 98.45 /HR

(1) ADJUSTMENT FOR NET ESTIMATED EFFECTIVE DAYS/MONTH = 16.73 DAYS / 30.42 DAYS/MO.

O P E R A T I N G C O S T S C O N T ' D

Filename: OCEANB1.WK3

4. PUMP AND PIPE WEAR AND REPAIRS

DESCRIPTION	TOTAL WEAR AND REPAIRS COSTS		
	MUD	SAND	GRAVEL
PUMP SIZE: 24''			
QUANTITY DREDGED (CY)	0	10,000	0
% PUMPOUT	100%	100%	100%
PUMPS:			
Dredge Pumps	$0	$450	$0
Pumpout Pumps	$0	$450	$0
SUBTOTALS: PUMPS -	$0	$900	$0
TOTAL PUMP WEAR..			$900
DISCHARGE PIPES:			

Estimated By: Ed Gonzales 22 Sep 94

Pumpout Line Length LF	D/wgrm/riwindo	D/wgrm/riwindo	D/wgrm/riwindow2
Pipe Wear Cost	$0	$0	$0
SUBTOTALS: DISCHARGE PIPES -	$0	$0	$0
TOTAL PIPE WEAR..			$0

TOTAL COST FOR PUMP AND PIPE WEAR AND REPAIRS: $ 900 TOTAL

AVERAGE COST PER CY EXCAVATED: $ 0.09 /CY

TOTAL COST/HR = TOTAL WEAR COST/(TOTAL EFFECTIVE+NON-EFFECTIVE HRS) =
= $900 / 51 HRS = $ 17.61 /HR

5. PROVISIONS & SUPPLIES

ACTUAL CREW = 14 EA
GOVERNMENT PERSONNEL ON DREDGE = 3 EA

TOTAL PROVISIONS @ (\$15.00/ MAN-DAY x 17 ea) / 24 HRS/DAY =	\$	10.63 /HR

SUMMARY

TOTAL HOURLY OPERATING COST	\$	216.68 /HR
TOTAL DAILY OPERATING COST = (\$216.68 x 24 HRS/DAY) =	\$	\$5,200 /DAY
TOTAL HOURLY FUEL COST DURING MOB & DEMOB.	\$	173.92 /HR
TOTAL DAILY FUEL COST DURING MOB & DEMOB = (\$173.92 x 24 HRS/DAY) =	\$	\$4,174 /DAY

Estimated By: Ed Gonzales 22 Sep 94

SUMMARY OWNERSHIP & OPERATING COST FOR: 3800 CYD HOPPER DREDGE

Filename: OCEANB1.WK3

	DREDGING RATES	MOB AND DEMOB RATES
1. OWNERSHIP:		
DEPRECIATION	$3,001 /DY	$3,001 /DY
MARINE INSURANCE	$1,000 /DY	$1,000 /DY
TAXES	$667 /DY	$667 /DY
LAYUP	$343 /DY	$343 /DY
YARD	$263 /DY	$263 /DY
a. SUBTOTAL, DAILY OWNERSHIP	$5,274 /DY	$5,274 /DY
b. SUBTOTAL, MONTHLY OWNERSHIP	$160,467 /MO	$160,467 /MO
2. OPERATING COSTS:		
FUEL	$2,019 /DY	$4,174 /DY
LUBRICANTS	$141 /DY	$141 /DY
REPAIRS AND MAINTENANCE	$2,363 /DY	
PUMP AND PIPE WEAR & REPAIRS	$423 /DY	
PROVISIONS AND SUPPLIES	$255 /DY	$255 /DY
a. SUBTOTAL, DAILY OPERATING COSTS:	$5,201 /DY	$4,570 /DY
b. SUBTOTAL, MONTHLY OPERATING COSTS:	$158,214 /MO	$139,019 /MO
3. TOTAL OWNERSHIP & OPERATING COSTS:		
a. DAILY OWNERSHIP & OPERATING COSTS	$10,475 /DY	$9,844 /DY
b. MONTHLY OWNERSHIP & OPERATING COSTS	$318,681 /MO	$299,486 /MO
4. COST OF FACILITIES CAPITAL or (IOI):		
a. DAILY CFC COSTS	$1,236 /DY	$1,236 /DY
b. MONTHLY CFC COSTS	$37,612 /MO	$37,612 /MO

USER VARIABLE DATA SUMMARY TABLE	VARIABLE USED	DEFAULT # FROM DATABASE
USE MONTHS PER YEAR (UMPY)	DEFAULT -->	9
CAPITAL IMPROVEMENT %	DEFAULT -->	10%
PUMP LOAD FACTOR DURING DREDGING.	DEFAULT -->	50%
REPAIR & MAINTENANCE COST ADJUSTMENT	DEFAULT -->	1.00

Estimated By: Ed Gonzales

22 Sep 94

EFFECTIVE DATE: 02 JUN 88

TABLE A. FUEL CONSUMPTION FACTORS

	FUEL FACTOR (GAL/BHP-HR)					
Type of Work	%	Propulsion factor	%	Pumps factor	%	Aux & Misc factor
Dredging	45	0.024	50	0.027	30	0.016
Haul and Return	80	0.042	0	0.000	25	0.013
Pumpout	0	0.000	80	0.042	25	0.013
Non-Effective	0	0.000	0	0.000	25	0.013

TABLE B. LUBRICANTS, REPAIRS AND MAINTENANCE.

TOTAL INSTALLED HP OF DREDGE	LUBE $/HR (1)	REPAIRS & MAINTENANCE $/HR (2)
0 - 3999 HP	$4.40	$109.00
4000 - 4999 HP	$5.65	$122.00
5000 - 5999 HP	$6.90	$136.00
6000 - 6999 HP	$8.15	$151.00
7000 - 7999 HP	$9.40	$165.00
8000 - 8999 HP	$10.65	$179.00
9000 - 9999 HP	$11.90	$193.00
10000 - 10999 HP	$13.15	$207.00
11000 - 11999 HP	$14.40	$221.00
12000 - 12999 HP	$15.65	$235.00
13000 - 13999 HP	$16.90	$249.00
14000 - 14999 HP	$18.15	$264.00
15000 - 15999 HP	$19.40	$278.00
16000 - 16999 HP	$20.65	$292.00
17000 - 17999 HP	$21.90	$306.00

(1) LUBRICANTS Includes materials only.
(2) Includes all repairs and maintenance to all components except pumps and discharge piping for pumpout, including parts, labor, small tools, equipment and drydocking.

TABLE C. COST DATA FOR PUMP & PIPE WEAR AND REPAIRS

	PUMP WEAR COST / CY		
DISCHARGE DIAM.	MUD	SAND	GRAVEL
16	$0.009	$0.028	$0.080
18	$0.010	$0.032	$0.091
20	$0.011	$0.037	$0.102
24	$0.014	$0.045	$0.124
28	$0.016	$0.054	$0.145
34	$0.020	$0.067	$0.178

	PUMPOUT PIPE WEAR COST / CY-LF		
DISCHARGE DIAM.	MUD	SAND	GRAVEL
12	$0.000020	$0.000026	$0.000040
14	$0.000018	$0.000023	$0.000035
16	$0.000015	$0.000020	$0.000031
18	$0.000014	$0.000018	$0.000027
22	$0.000012	$0.000016	$0.000024
27	$0.000011	$0.000014	$0.000021
30	$0.000010	$0.000011	$0.000018

PROJECT ______________________ INVIT. NO. __________ SHEET _____ OF _____

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BID ITEM # 2 G MOB & DEMOB

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NAME OF DREDGE SMALL SIZE HOPPER

		MOB. # DAYS	DEMOB. # DAYS
1. PREPARE DREDGE FOR TRANSFER		1	1
2. TRANSFER ALL PLANT 300 MILES @ 9 miles/hour =		1.4	
3. TRANSFER ALL PLANT 300 MILES @ 9 miles/hour =			1.4
4. PREPARE DREDGE AFTER TRANSFER		0.5	0
5. TOTAL DAYS (MOB. & DEMOB)		5.3 days	
6. DAILY MOB. & DEMOB. RATE		x $21,377 per day	
7. SUBTOTAL		= $113,298	
8. SPECIAL COSTS (DESCRIBE)		$5,000	$0
		$0	$0

9. SUBTOTAL MOBILIZATION & DEMOBILIZATION		=		$118,298
10. OVERHEAD	15.0%	=	$17,745	$17,745
11. PROFIT	8.0%	=	$10,883	$0
12.				$0
13. BOND	1.0%	=	$1,469	$1,469
14. TOTAL MOBILIZATION & DEMOBILIZATION		=		$137,512

OCEAN BEACH SAND DUNE NOURISHMENT

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HAULING: SAND FROM SOURCE: 65 MILES 45 MPH KAISER SAND AND GRAVEL

EQUIPMENT USED:	20 DUMP TRUCKS 5 CY LOADER			
CAPACITY:	20 CY			
TRIP TIME:	3.21 HOURS PER TRIP			
NO. OF TRIPS:	3.12 PER DAY			
PRODUCTION:	1248 CY PER DAY			
QUANTITY:		65000 CY	35000 CY	124000 CY
DURATION:		53 DAYS	29 DAYS	102 DAYS

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PLACING SAND:

EQUIPMENT USED:	1 DOZER 125 CY EACH			
WORK DAY:	10 HR-DAY			
PRODUCTION:	125 CY/HR 50 MIN-HR			1250 CY/DAY
QUANTITY:		65000 CY	35000 CY	124000 CY
DURATION:		53 DAYS	29 DAYS	102 DAYS

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OCEAN BEACH SAND DUNE NOURISHMENT

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HAULING: SAND FROM SOURCE: 30 MILES 45 MPH TIDEWATER SAND AND GRAVEL

EQUIPMENT USED:	12 DUMP TRUCKS 5 CY LOADER			
CAPACITY:	20 CY			
TRIP TIME:	1.65 HOURS PER TRIP			
NO. OF TRIPS:	6.06 PER DAY			
PRODUCTION:	1455 CY PER DAY			
QUANTITY:		65000 CY	35000 CY	124000 CY
DURATION:		46 DAYS	25 DAYS	87 DAYS

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PLACING SAND:

EQUIPMENT USED:	2 DOZER 74 CY EACH			
WORK DAY:	10 HR-DAY			
PRODUCTION:	148 CY/HR 50 MIN-HR			1480 CY/DAY
QUANTITY:		65000 CY	35000 CY	124000 CY
DURATION:		45 DAYS	24 DAYS	86 DAYS

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OCEAN BEACH SAND DUNE NOURISHMENT

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HAULING: SAND FROM SOURCE: 65 MILES 45 MPH KAISER SAND AND GRAVEL

EQUIPMENT USED:	20 DUMP TRUCKS 5 CY LOADER		
CAPACITY:	20 CY		
TRIP TIME:	3.21 HOURS PER TRIP		
NO. OF TRIPS:	3.12 PER DAY		
PRODUCTION:	1248 CY PER DAY		
QUANTITY:	125000 CY	175000 CY	200000 CY
DURATION:	103 DAYS	144 DAYS	164 DAYS

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PLACING SAND:

EQUIPMENT USED:	1 DOZER 125 CY/HR EACH		
WORK DAY:	10 HR-DAY		
PRODUCTION:	125 CY/HR 50 MIN-HR		1042 CY/DAY
QUANTITY:	125000 CY	175000 CY	200000 CY
DURATION:	123 DAYS	172 DAYS	197 DAYS

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OCEAN BEACH SAND DUNE NOURISHMENT

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HAULING: SAND FROM SOURCE: 35 MILES 45 MPH TIDEWATER SAND AND GRAVEL

EQUIPMENT USED:	12 DUMP TRUCKS 5 CY LOADER		
CAPACITY:	20 CY		
TRIP TIME:	1.87 HOURS PER TRIP		
NO. OF TRIPS:	5.34 PER DAY		
PRODUCTION:	1282 CY PER DAY		
QUANTITY:	125000 CY	175000 CY	200000 CY
DURATION:	100 DAYS	140 DAYS	160 DAYS

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PLACING SAND:

EQUIPMENT USED:	1 DOZER 125 CY/HR EACH		
WORK DAY:	10 HR-DAY		
PRODUCTION:	125 CY/HR 50 MIN-HR		1042 CY/DAY
QUANTITY:	125000 CY	175000 CY	200000 CY
DURATION:	123 DAYS	172 DAYS	197 DAYS

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OCEAN BEACH SAND DUNE REFURBISHMENT PROJECT

	UNIT COST	10000 CY	75000 CY	125000 CY	175000 CY	200000 CY
MEGA SAND INC. DECKER ISLAND	$8.90	$89,000	$667,500	$1,112,500	$1,557,500	$1,780,000
DEL. COST	$9.15	$91,500	$686,250	$1,143,750	$1,601,250	$1,830,000
LABOR COST	INCL IN COST	$0	$0	$0	$0	$0
REVEGETATION	$1.80	$18,000	$135,000	$225,000	$315,000	$360,000
OVERHEAD	15%	$29,775	$223,313	$372,188	$521,063	$595,500
PROFIT	8%	$18,262	$136,965	$228,275	$319,585	$365,240
BOND	1%	$2,465	$18,490	$30,817	$43,144	$49,307
CONTINGENCIES	15%	$37,350	$280,128	$466,879	$653,631	$747,007
S & A	0%	$0	$0	$0	$0	$0
TOTAL COST		$286,353	$2,147,645	$3,579,409	$5,011,173	$5,727,055

TIDEWATER SAND & GRAVEL, PRESIDIO	$6.41	$64,100	$480,750	$801,250	$1,121,750	$1,282,000
DEL. COST	$5.85	$58,500	$438,750	$731,250	$1,023,750	$1,170,000
LABOR COST	$5.75	$57,500	$431,250	$718,750	$1,006,250	$1,150,000
REVEGETATION	$1.80	$18,000	$135,000	$225,000	$315,000	$360,000
OVERHEAD	15%	$29,715	$222,863	$371,438	$520,013	$594,300
PROFIT	8%	$18,225	$136,689	$227,815	$318,941	$364,504
BOND	1%	$2,460	$18,453	$30,755	$43,057	$49,208
CONTINGENCIES	15%	$37,275	$279,563	$465,939	$652,314	$745,502
S & A	0%	$0	$0	$0	$0	$0
TOTAL COST		$285,776	$2,143,318	$3,572,196	$5,001,075	$5,715,514

	UNIT COST	10000 CY	75000 CY	125000 CY	175000 CY	200000 CY
KAISER SAND AND GRAVEL, STA. CZ	$10.40	$104,000	$780,000	$1,300,000	$1,820,000	$2,080,000
DEL. COST	$14.76	$147,600	$1,107,000	$1,845,000	$2,583,000	$2,952,000
LABOR COST	$5.75	$57,500	$431,250	$718,750	$1,006,250	$1,150,000
REVEGETATION	$1.80	$18,000	$135,000	$225,000	$315,000	$360,000
OVERHEAD	15%	$49,065	$367,988	$613,313	$858,638	$981,300
PROFIT	8%	$30,093	$225,699	$376,165	$526,631	$601,864
BOND	1%	$4,063	$30,469	$50,782	$71,095	$81,252
CONTINGENCIES	15%	$61,548	$461,611	$769,351	$1,077,092	$1,230,962
S & A	0%	$0	$0	$0	$0	$0
TOTAL COST		$471,869	$3,539,017	$5,898,361	$8,257,706	$9,437,378

GREAT LAKES	$10.00	$100,000	$750,000	$1,250,000	$1,750,000	$2,000,000
DEL. COST	INCL IN COST	$0	$0	$0	$0	$0
LABOR COST	$5.75	$57,500	$431,250	$718,750	$1,006,250	$1,150,000
REVEGETATION	$1.80	$18,000	$135,000	$225,000	$315,000	$360,000
OVERHEAD	15%	$26,325	$197,438	$329,063	$460,688	$526,500
PROFIT	8%	$16,146	$121,095	$201,825	$282,555	$322,920
BOND	1%	$2,180	$16,348	$27,246	$38,145	$43,594
CONTINGENCIES	15%	$33,023	$247,670	$412,783	$577,896	$660,452
S & A	0%	$0	$0	$0	$0	$0
MOB & DEMOB		$500,000	$500,000	$500,000	$500,000	$500,000
TOTAL COST		$753,173	$2,398,800	$3,664,666	$4,930,533	$5,563,466

Note: Great Lakes is not willing to give any cost qoute other than the range of unit cost of $6.00 to $10.00 and MOB of about $500K.

ESTIMATED BY ______________ DATE ________ CHECKED BY ______________

	UNIT COST	10000 CY	75000 CY	125000 CY	175000 CY	200000 CY
DUTRA CONST. CO. SETTLE, WA.	$10.00	$100,000	$750,000	$1,250,000	$1,750,000	$2,000,000
DEL. COST	$9.15	$91,500	$686,250	$1,143,750	$1,601,250	$1,830,000
LABOR COST	INCL IN COST	$0	$0	$0	$0	$0
REVEGETATION	$1.80	$18,000	$135,000	$225,000	$315,000	$360,000
OVERHEAD	15%	$31,425	$235,688	$392,813	$549,938	$628,500
PROFIT	8%	$19,274	$144,555	$240,925	$337,295	$385,480
BOND	1%	$1,688	$12,654	$21,089	$29,524	$33,741
CONTINGENCIES	15%	$25,576	$191,702	$319,492	$447,281	$511,176
S & A	0%	$0	$0	$0	$0	$0
TOTAL COST		$287,463	$2,155,848	$3,593,068	$5,030,287	$5,748,897

Note: DUTRA CONST. CO. is very reluctant to give any cost. DUTRA said it is unsafe for the equipment in that area. MOB is about $50K per equipment they bring to project. MOB still needs to be added to the cost.

GOV'T ESTIMATE	$7.95	$79,500	$596,250	$993,750	$1,391,250	$1,590,000
DEL. COST	$12.00	$120,000	$900,000	$1,500,000	$2,100,000	$2,400,000
LABOR COST	$5.75	$57,500	$431,250	$718,750	$1,006,250	$1,150,000
REVEGETATION	$1.80	$18,000	$0	$0	$0	$0
SUB-TOTAL (BARE COST)		$257,000	$1,927,500	$3,212,500	$4,497,500	$5,140,000
OVERHEAD	15 %	$38,550	$289,125	$481,875	$674,625	$771,000
PROFIT	8 %	$23,644	$177,330	$295,550	$413,770	$472,880
BOND	1 %	$3,192	$23,940	$39,899	$55,859	$63,839
CONTINGENCIES	15 %	$48,358	$362,684	$39,899	$745,069	$967,158
S & A	0%	$0	$0	$0	$0	$0
TOTAL COST		$370,744	$2,780,579	$4,069,724	$6,386,823	$7,414,877